GROW Observatory

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DELIVERABLE 1.4

Mission Outcomes

Report

DELIVERABLE 1.4

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Summary

The GROW Observatory has a vision to support the emergence of a movement of citizens generating, sharing and using information on growing and the land. Whilst there is an overarching vision to address land use and management issues, a key scientific objective is to ground-truth sentinel 1 products using in-situ crowdsourced soil moisture data. To do this we have run a series of Missions, defined a model and co-design approach to support citizens to measure land and soil parameters at high spatial resolution over large geographical areas, generating a unique soil and land data repository.

This deliverable, reports on mission outcomes around the adoption of sustainable land management practices, land use change, and validation of new land management and cultivation practices. Missions are at-a-scale citizen science activities and mass online social learning programmes, which are designed to engage thousands of growers, scientists, policy makers as well as strengthening connections with citizen associations, NGOs, scientific and academic institutions. We describe the process of development of the methods used for the design approach to Citizen Science activities and Missions, i.e. the GROW Framework, which reflects the ambition to increase public awareness and learning, but also to move beyond this by providing information and to support citizens to be agents of change.

We include an in-depth and visual review of activity evidencing GROW missions' impacts. This includes evaluations and outcomes from the final mission insights workshops sessions carried out with communities and stakeholders. This report comprises five sections:

Section 1 Describes the context for GROW, to move beyond state-of-the-art citizen science by scaling up and bridging issues for stakeholders involved. We present the iterative development of the final GROW Framework, and describe the values that sit alongside it.

Section 2 presents The Changing Climate Mission. Evaluation methods and results are presented, this includes an overview, new tools developed to support citizen science evaluation in GROW Places. Evaluation tools and case studies that were co-created with Community Champions to capture feedback and the experiences of participating communities.

Section 3 presents The Living Soils Mission including the results of the Great GROW Experiment, and the contribution of crowdsourced activity for the Edible Plant Database.

Section 4 & 5 Summarise outcomes from the Missions overall, including lessons learned for Citizens Observatories and presents a conclusion for the report.

Definitions

We provide definitions for the key terms covered in this deliverable below. Definitions for other commonly used terms in GROW can be found in the GROW glossary, available on the GROW Knowledge Base:
https://knowledge.growobservatory.org/wp-content/uploads/2019/01/GROWglossary2019.pdf

Citizens' Observatory (CO), a concept coined by the European Commission, refers to a community of stakeholders which include citizens, scientists, policymakers and others collaborating on research for environmental monitoring, whose issues have impacts related to land cover and land use.

Collaboration Hub (CH) is a place to be part of the GROW community and to connect and discuss with other stakeholders. It is also where people connect their soil sensor to the GROW database and where they can see their sensor data. CH is an internal term GROW uses to describe the online social platform in GROW.

Community Champions are members of the community that coordinated soil sensing activities with citizen scientists as part of the Changing Climate Mission in GROW Places. Champions are in charge of recruiting sensor users, engaging local growers' networks of growers and other stakeholders, organising local events and acting as representatives of their communities with the GROW team. Champions in the GROW project were issues with a contract and received a small financial sum for their coordination work.

GROW Places (GP) are geographic focus areas. GROW Places deliver a minimum viable, high density distribution of sensors across geographically diverse areas, using geographic and scientific criteria, designed for scientific exploitation, enabled by the participation of a place-based community.

Mission is a period of coordinated citizen science activity that can involve sensing and sense making for citizen-generated data. Missions engage citizens,

scientists, policy makers and other stakeholders. Missions are designed to achieve social, policy and innovation outcomes with sustainable impacts.
Missions engage citizens, scientists, policy makers and other stakeholders. Missions are designed to achieve social, policy and innovation outcomes with sustainable impacts.

MOOC as it is commonly known stands for Massive Open Online Course, aimed at a learning journey featuring traditional educational materials, and interactions with the community of learners and educators. MOOCs are open to an unlimited number of learners and are open access via the web. GROW reached an agreement with FutureLearn (the leader platform on MOOCs) to maintain the course content available to participants for an unlimited time after the end of the run and until the end of the project.

Personal Data means any information, private or professional, which relates to an identified or identifiable natural person (for the full definition, see Article 2(a) of EU Directive 95/46/EC).
Repository A digital repository is a mechanism for managing and storing digital content. Repositories can be subject or institutional in their focus. (http://www.rsp.ac.uk/start/before-youstart/what-is-a-repository/).

Superuser in the context of the GROW project, refers to citizen scientists who a) manage many sensors, and might also b) push the limits of current system specifications and capacity to develop or request the development of new ways of visualising, sharing or accessing citizen-generated sensor data, such as sharing datasets on GitHub.

Introduction

Over the last three years, The GROW Observatory, has run a series of at-a-scale citizen science activities and mass online social learning programmes engaging thousands of growers, scientists and policy makers on the way. GROW has created resources, citizen-generated datasets and new collaborations to foster learning and climate action using soils and food growing as an entry point for engagement and participation. GROW's vision is to support the validation of sentinel 1 satellite products for soil moisture through the emergence of a movement of citizens generating, sharing and using information on growing and the land. GROW has realised its vision by enabling citizens to measure land and soil parameters at high spatial resolution over large geographical areas, generating a unique soil and land data repository for science. Additionally, GROW has supported growers to learn about and test new practices, guiding their knowledge to foster the integration of regenerative techniques into their existing land and soil management routines.

GROW positioned its citizen sensing and observations around the framing of Missions as a means to engage stakeholders in the overarching observatory aim. In years two and three of the project, Work Package 1 (WP1) has delivered the Living Soils Mission and the Changing Climate Mission. In this deliverable we describe and evaluate how each of these two missions have contributed to fostering the adoption of sustainable land management practices, land use change, and validation of new land management and cultivation practices. To provide some background context, we start with a short summary of each Mission:

The Changing Climate Mission

Soil moisture data has been a key focus in the Changing Climate Mission, with an objective to test the data quality and the spatial representativity in differing use cases of citizen measurements, ultimately to improve understanding and uptake of crowdsourced soil moisture data. Soil moisture is an ever-changing property, and observations over geographic regions are fundamental for many issues that are increasing affecting the everyday lives of people, such as drought, floods, heatwaves and global climate predictions. Soil moisture also serves as a key input parameter in erosion estimations and is a driving parameter of soil biological activity and diversity, organic matter development, hence carbon sequestration (Kovács, KZ et al, 2019).

The Changing Climate mission has provided the context for the suite of activities that focused on sensor distribution and deployment to meet Copernicus requirements for service innovation. It has also contributed to enhancing public awareness of the connection between soil, satellites and climate science, and how living in a changing climate affects people's everyday lives and growing practices; this mission has also achieved the creation of novel citizen-generated soil moisture data that has been used to validate soil moisture monitoring by satellites, and which can help to improve forecasting on extreme climate events In year 2 and 3 Mission activities took place in an expanding network of GROW Places across Europe. These are supported by local Community Champions Organisations. These are registered legal entities which are contracted by the Permaculture Association Britain on behalf of GROW to deliver the Mission in their GROW Places. The development and strategy for the GROW Places network and the Community Champion scheme are discussed in detail in the public Deliverable 2.4 Community Champions Programme.

Activities in this Mission supported the following science, social and policy related ambitions in GROW:

Impact 3 Evidence-based and technology-enabled decision making and the active participation of citizens around land and soil governance.

Impact 5 Enhance and validate land/soil management practices and production techniques.

Impact 6 Provide a contribution towards the generational renewal in European agriculture through training and building connected rural communities.

Impact 7 Citizens empowered to cultivate land and access affordable and high-quality food by growing their own with regenerative methods that do not require high cost agricultural inputs.

Impact 9 Enable the Global Soil Partnership (GSP) to better achieve sustainable soil management in the European region through training on soil and participatory governance as well as promoting and capturing policy impacts in participating communities.

Impact 11 Enable, promote and evidence sustainable micro-farming, diversification and self-reliance.

Impact 19 Potential for extension of GROW Observatory to developing nations and regions (e.g. Sahel).

Impact 23 Introduce new target groups of potential end-users to Earth observation and in situ monitoring products and services.

The Living Soils Mission

It is proposed that regenerative soil management and land use practices are vital for environmental and economic sustainable, rural development, food security, biodiversity conservation, climate change adaptation and protecting water resources. The trend for rural land cover and land use in Europe continues to be intensive, monoculture agriculture. This can lead to biodiversity loss, climate change and rural depopulation, and has been shown to contribute to soil degradation (FAO, 2019). This urgent issue has created a need to enable, promote and evidence small-scale growing and regenerative food practices as viable alternatives. From the beginning of the project, GROW team has been explicit in its aim to move beyond providing data and information to support citizens to make changes to their practices. Furthermore, GROW has provided a positive and proactive angle to climate change mitigation, offering opportunities for action at the relevant scale to thousands of citizens.

This Mission has developed and supported an active network of small-scale food growers and gardeners by using and collaboratively investigating cultivation practices to provide a key dataset and more evidential approach to regenerate soils and create more resilient ecosystems at small scale growing. The mission has addressed four key issues:

I. A lack of knowledge and academic research into food growing practices and European potential at the smaller (i.e. not routinely mechanised) scale of growing, and widespread sharing of poor-quality information amongst growers.
II. A lack of location-specific information and advice for growers.
III. Related to the above, there are no channels for gathering and validating data on planting and harvesting edible crops in a changing climate.
IV. A need for free and validated information on effective regenerative approaches to growing to improve soils, promote biodiversity and ecosystem integrity, bolster climate change resilience, and enhance local access to high-quality food.

In response to the above issues, the Living Soils Mission produced a series of brand new resources, and learning and experimenting opportunities including: A collective growing experiment (polycultures vs monocultures), a new mobile app with local growing advice and MOOCs covering regenerative techniques and how to design your own growing experiments. All the details are discussed in section 6 of this deliverable.

1. Beyond Monitoring: An Observatory in Practice

Citizen Observatories have the potential to support citizens to act as agents of change, by participating in knowledge creation, decision-making and governance at all scales. GROW's objective was to move beyond state-of-the-art citizen science by adopting a rigorous and replicable framework underpinned by a mission-based approach to scoping, scaling up and bridging issues for all stakeholders involved in the Observatory.

The GROW Framework

In this section, we describe the development process and components of the final GROW Framework in the hope that it can inform and inspire future consortia and/or communities keen to set up new Observatories. The main purpose of the framework is to offer a **transferable model** to support Observatories' activities, regardless of the type of environmental topic they are focusing on.

The framework builds on the findings of key literature as well as on the experience from previous EU projects delivering citizen science activities (Making Sense, 2018) and reflects on practice in GROW.

In terms of practice, the framework is based on insights from carrying out initial pilot Missions (Overwinter Mission, From Soil to Sky Mission, Nutrient Testing Kit Validation Mission and Sensing Mission) and has been refined and validated during subsequent Missions in years 2 and 3. Additionally, the framework has informed and been informed by:

- guidelines for scoping environmental issues in collaboration with citizens
- factors that mobilise, support and empower individuals and communities
- appropriate online and physical knowledge exchange tools for citizens, communities, agencies and policy makers
- a unified approach for engaging with partners and community champions
- development of proposed business model

A significant contribution of the framework is to provide a set of stages that take into account the practice, science and governance dimensions that COs bring together. These stages are designed to illustrate the ideal journey of participation in the Observatory that in turn informs the design, delivery and infrastructuring of an endeavour.

The process model is reflected as a cycle to represent a distinctive dimension we consider to be critical for COs, which is the focus on closing the loop: from environmental issues to data collection with robust protocols, development of critical innovative climate services, back to citizens, experts and policy makers. It is important to highlight however, that the stages do not always follow a chronological order. Evidence from three years of GROW has proved that as expected, the rich experience of participation does not happen in tidy or clearly defined stages. The framework acknowledges that feedback loops and reiteration of stages are often required, which foster consolidation of knowledge and innovation (e.g. scoping new issues with communities during the Awareness stage can lead to innovations, such as those described in Section 2.5 Evaluating Impact: Data Innovation).

Building on previous theory the framework is informed by Shirk and colleagues' research on public participation in scientific research to help balance inputs from scientific and public interests to enhance outcomes for scientific research, individual participants, and social–ecological systems (Shirk et al., 2012). The concept of "Mission" was used to organise and coordinate citizen science activities, in principle, taking participants through each of the stages of the framework. Missions as a concept builds on the Campaign framework from the H2020 Making Sense project. (http://making-sense.eu) The Missions framework promotes a model of social learning involving the integration of the different "frames" of stakeholders. Frames influence how people see reality. For example, engineers, ecologists, lawyers, environmentalists, and farmers (and even different types of farmers) will all have quite different views and reference frameworks. They each perceive different aspects, construct a different image of functions, observe different problems, view each other differently, and perceive different solutions. The Missions, informed by the framework, were designed to bridge

between citizen and official, between sectors and disciplines, rural and urban, technological and natural, and between local, regional, national and pan-European scales.

WP1 Deliverable 1.1 *GROW Citizens' Observatory Framework* described Version 1.0 (v1.0) of the framework with the plan to effectively develop, evaluate and replicate it throughout the project mission activities. The framework v1.0 was proposed as a seven-stage process model process for the design, delivery and impact of CO projects, underpinned by four cross-cutting values.

GROW PHASES	DESCRIPTION	ACTIVITIES
SCOPING	Map identify issues, positioning missions, infrastructure, participants, data, services, criteria	Research citizens, experts, Policy / mapping issues and concerns, problem and product day, gap analysis, citizen science, best practices for CO's
COMMUNITY BUILDING	Recruitment, onboarding citizens, experts, policy makers	Engagement and communications with kindred networks, community, storytelling, thematics, media partnerships, community champions
DISCOVERY	Education and building understanding, context, science, protocols, mission aims and objectives	Learning and training, data literacy, peer and social knowledge exchange
SENSING	Data gathering and observations using technology and with citizens, sharing data	Senor distribution, deployment, data upload and access
AWARENESS	Data literacy, analysis, application and action	Webinar, workshops, celebration, data access, aggregation, sharing insights, scientific or expert interpretation, critical

		reflection with citizens
INNOVATION	New datasets, prototyping and testing services with users, validating CO platform and infrastructure	Design for new services, business proposals, new resources and assets for communities, robust protocols and datasets
ADVOCACY	Policy, soil, services, technology, robust data, CO approach	Championing, BI-laterals, change: in practice, policy, uptake, external application, sustainability of the project and tools, outputs, interventions

Cross-cutting values

GROW is defined by its values, and they underpin the framework (V 1.0). These values inform the implementation of the framework in project design and delivery, and are formalised in policies such as data governance, and the emphasis on citizens as stakeholders in the project:

Empowering: In GROW, there is advocacy for the value of citizens becoming empowered to adopt an active relationship to each other, to their environment, and to data and knowledge.

Collaboration: GROW is social peer-to-peer, and as citizen-led as it can be, always looking for new ways to be more so. There are some limits to this, due to the focus on scaling, and the need to meet some pre-defined scientific goals.

Open: There is a commitment to open and collaborative knowledge, and to the value of sharing data, making it visible and accessible, and to enabling people to make sense of data themselves.

Impactful: There is a focus on bringing about positive change in the world, addressing significant data gaps, developing useful services, and creating sustainability for community, data, infrastructure and the project.

In addition, there are also intrinsic values that relate to the concept of COs, such as connecting the hyperlocal with planetary monitoring and their key role as

translators of data and of different types of knowledge and expertise across diverse stakeholder groups.

1.1.1 Iteration process for framework validation

As mentioned in the previous section, the framework builds on our findings and previous experience delivering citizen science activities. To move this conceptualisation forward, the process model was validated with the GROW Consortium during the General Assemblies that took place in Vienna in September 2017 and in Dundee in September 2018. During these Assemblies, dedicated sessions were held to review and refine the model stages and values from the perspective of each Work Package involved in the project.

In this regard, the insights from the experts corroborated the validity of current framework **stages** with overall consensus, a couple of minor improvements were suggested:

- Replace *Impactful* with *change-making*, *game-changing* or *rewarding*, as the word "impact" was considered to convey a dramatic top down approach.

- Incorporate *Governance* in the framework: Governance was proposed as a new stage or as a highlight in the description of Advocacy. This move would emphasise how COs bring together different levels of expertise and knowledge to create positive change at different levels in the way soils, land and food production methods are managed. At the same time, the governance context is something that COs, growers and more generally citizens, exist in, and this dual internal and external governance dimension could be represented as an exterior circle in which COs are embedded, both shaping and being shaped by it. Additionally, "better world governance" also acts a value to emphasise the open, de-centralised and peer to peer CO community, which needs to be better incorporated for the sustainability of the project (e.g. as GROW has experience first-hand, private technologies and platforms are not guaranteed to be supported in the long term). Tools, technologies and methodologies all require clear open licenses.

The findings in relation to framework **values** reflect the wide-ranging multi-stakeholder and multi-objective character of COs. As the project developed, the original list of values expanded as the delivery of activities and the creation of datasets generated new questions about the main objectives and principles an Observatory should adhere to. As a result, GROW experts concluded the number of

values relevant to Observatories to be much more widespread. The table 1 below summarises the list of values proposed and a range of categories to reflect what CO dimensions they refer to.

List of values Version 1	Process	Outcomes / Outputs
Relevant	Sharing	Educational
Future-inspired	Inclusive	Uniting
Open		
Value-full (social, economic, etc)	De-centralised	
Beneficial	Efficient	Empowering
Sustainable	Adaptive	Sustainable and adaptive

Table 1.1 Overarching values for a "High Tech & High Touch" Citizens' Observatory - CS principles

The CO values have a dual character: they refer to both intrinsic and extrinsic dimensions of COs, i.e. both the way the CO runs (e.g. approach to activities and resources design), as well as the conditions and openness of any resulting outputs (e.g. datasets, tools, research, etc) and the impacts they achieve in society. As with the stages, the reality of multi-stakeholder and multi-objective COs means some of the categories overlap.

In 2019, the framework was tested under a new recruitment and engagement strategy based on a dual process of amplification and replication of GROW Places. Amplification referred to expanding the number of participants and stakeholder involvement in existing GROW Places. Replication in turn was a parallel approach taken to increase the number of GROW communities in Europe to reach more countries and different socio-economic, cultural and geographical contexts. The GROW Places engagement methodology, described in Deliverable 2.4 *Community Champions Programme,* provided the evidence of scalability and replication of the concept of COs and the GROW Framework. The achievements of the Missions highlighted the theoretical potential of the framework to be relevant to diverse engagement and recruitment strategies and different cultural contexts.

1.1.2 A framework for replicability

Throughout the project, GROW had in mind not only the aim of demonstrating the concept of COs, but also the aspiration to develop a replicable model. Several dimensions of the Observatory showed clear potential for replicability, including beyond European borders, we list them here: GROW's learning model, crowdsourced data approaches, collective up-scale citizen science experiments and the novel recruitment and engagement strategies. Specific recommendations to maximise the benefits of these CO elements, as well as aspects to keep in mind to adapt them to local contexts, were presented in detail in D3.2 *Replicability of GROW CO outside EU*.

The framework offers a tool for future consortia or communities interested in setting up their own observatory within the EU or beyond. There is potential to export of GROW beyond the borders of the EU (WP3). The possibility to develop a bottom up map of soil moisture conditions over large areas represent an asset for the long-term legacy of the project as the details of the infrastructure that has been put in place and all the resources developed have been made publicly available where possible, to support other countries and regions for which soil moisture is more directly relevant to farming practice.

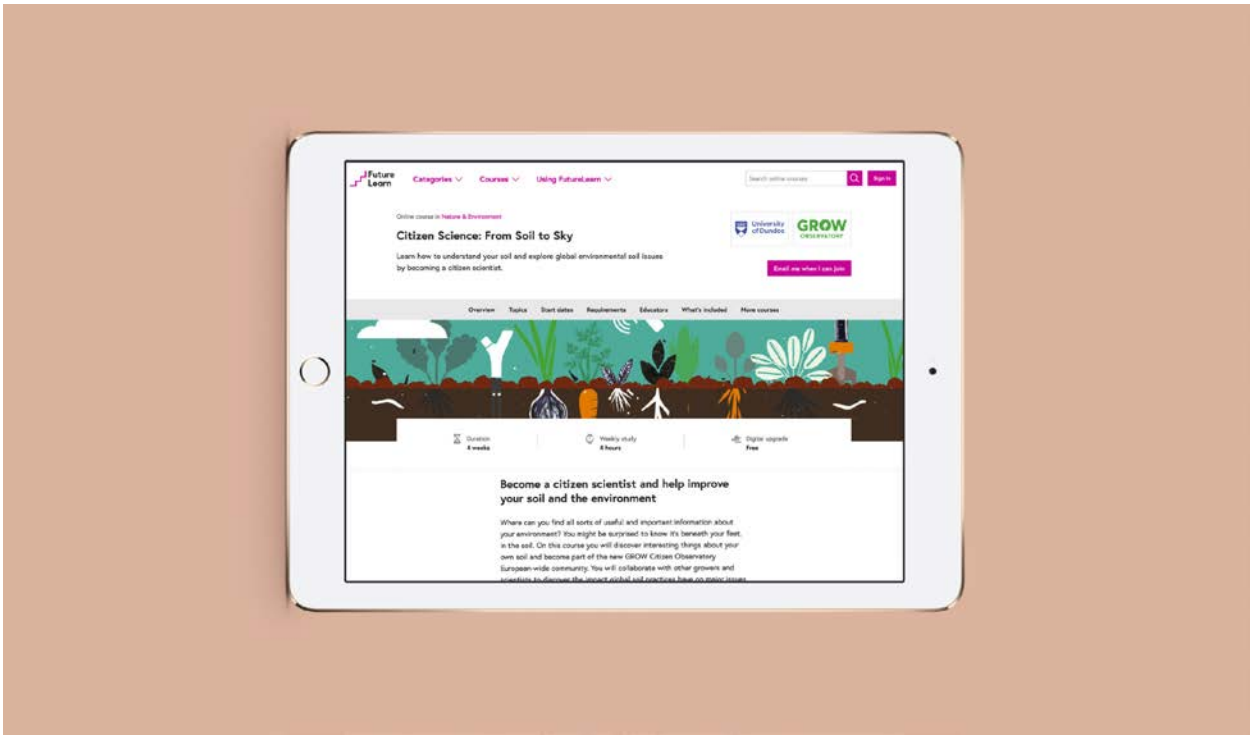
1.1.3 New Methods for Citizen Observatories

One distinctive aspect of the concept of Citizen Observatories is to substantially scale up participation whilst maintaining the collaboration of stakeholders. Scaling up engagement whilst maintaining the values and principles for collaboration, as well as quality and relevance is notoriously difficult to achieve. Many citizen science and observatory initiatives foster active participation by adopting a co-design or co-creation approach, whilst success can be achieved with these methods in tackling issues, these approaches are intensive to scale. On the other hand, citizen science and observatories can attract high numbers of participants that contribute data but forego more active collaboration and thus empowerment, which is necessary for change-making in practice.

GROW aimed to have both scale and active participants in order to meet the requirements for sensor distribution, density and geographical spread of soil moisture measurements and to address innovation outcomes. This necessitated a novel approach using social and peer to peer engagement, training and education whilst at the same time building community. Thus, the framework described in section 1.1 earlier in this report was complemented with complete set of new resources, a detailed account of these have been provided in WP1 D1.3 *GROW Missions Toolkit*.

In the following sections, we describe the primary novel approaches to scaling for active participation in GROW.

1.1.4 Up-scaling Citizen Science through Massive Open Online Courses (MOOCs)



Through a MOOC 2.0 approach GROW was uniquely able to scale participation while maintaining scientific rigour for complex protocols. MOOCs allowed the project to engage with and train thousands of participants in the use of sensors, nutrient testing kits; land and soil survey; methods design; data collection and data awareness. Learners who were not directly involved in GROW were also able to join from around the world, thus paving the way for future efforts. Uniquely, the MOOC platform also provided the necessary data to be able to assess and evaluate how learners were progressing, for instance by tracking which steps of a course or topic attracts more comments and questions. Further details about the pedagogical approach used for the MOOCs can be found on this short conference paper:

	Massive Online Open Citizen Science Use of MOOCs to scale rigorous Citizen Science training and participation


Use of MOOCs to scale rigorous Citizen Science and its impact

The GROW MOOC learning programme brought together the wide range of expertise in the consortium to create a transdisciplinary set of courses covering soils, food growing, sensing technology, citizen science and earth observation. Each course had a dedicated trailer (all trailers are accessible on the GROW YouTube channel: https://www.youtube.com/watch?v=GXcivZguEwQ). Learners were offered two routes through the program: Changing Climates or Living Soils, Growing Food. Learners could choose a route or take both. Each route began with:

Course 1: Citizen Research: From Soil to Sky

Description: This first course provided an introduction to the GROW Observatory, soil science, challenges facing soils and potential solutions, as well as an overview of regenerative food growing practices.

Duration: 4 weeks. Recommended hours of study: 4 hours a week, flexible learning.

After taking this first course, learners could then, either choose one of the next two courses or take both:

Course 2: Citizen Research: Living soils, Growing food

Description: This course introduced learners to Earth Observations, satellite missions and citizen sensing. It immersed participants in the history, present and future of citizen science, open data and DIY technology. Learners were able to explore how widely available soil sensors combined with satellite data can help understand and predict our changing climate.

In the 2019 iteration the course had an extra week including content on GROW's latest data art and how to handle and analyse soil sensor data, as well as an introduction to other environmental open datasets to up-skill citizen scientists to carry out their own research.

Duration: 3 weeks. Recommended hours of study: 3 hours a week, flexible learning.

Course 3: Citizen Research: Sensing the world

Description: People who took part were able to learn about the challenges facing our food and farming systems and solutions to overcome them. In this course learners were also guided through the steps they had to follow to design their own growing experiments. This route encouraged learners to find out more about participatory governance and offer practical information on how to create positive change using citizen-generated data in their garden, local area and beyond.

The 2019 iteration of the course included content on how to move from data to action, and introduced learners to community action and participatory governance. Participants also learnt to design their own food growing research projects.

Duration: 3 weeks. Recommended hours of study: 3 hours a week, flexible learning.

Course 4: Citizen Research: From data to action

Description: This course presented the growing, soil and harvest data collected by small scale growers over the 2018 growing season. We discussed how growers can gather, understand and use data to inform and change growing practices. The course also covered the gap between data and users and data and practical uses and policy. Participants were also introduced to the new and free GROW Observatory app for planting advice.

Duration: 3 weeks. Recommended hours of study: 3 hours a week, flexible learning.

An overview of all enrolment statistics for each iteration of the MOOCs can be seen in Table 1.2. A description of each learner category and how statistics are collected by FutureLearn can be found in Appendix 1. Appendix 2 shows Comparative enrolment figures for other FutureLearn courses in same subject category as GROW MOOCs.

MOOC n.	Title	Date	Joiners	Active learners	Social learners	Learners with ≥50% step completion	Learners with ≥90% step completion	Data collected

MOOC1 Iteration 1	Citizen Science: From Soil to Sky	8/5/17-26/5/17	2,145	919	414	218	148	-Slope angle and aspect -Land cover and canopy cover -Soil texture and stone content data -Regenerative food growing practices
MOOC1 Iteration 2	Citizen Science: From Soil to Sky	19/2/18-16/3/18	4,388	2,079	1,096	743	378	-Soil texture & stone content -Slope angle & canopy cover -Regenerative food growing practices
MOOC2 Iteration 1	Citizen Science: Sensing the World	26/3/18-6/4/18	1,342	555	258	307	226	-Sensors used by learners -CS projects learners are involved with
MOOC3 Iteration 1	Citizen Science: Living Soils, Growing Food	16/4/18-4/5/18	3,128	1,471	651	440	153	-Regenerative practices -Polyculture experiment parameters -Land and Soil survey
MOOC4 Iteration 1	Citizen Science: From Data to Action	5/11/18-23/11/18	1,110	780	132	129	105	-Follow up evaluation survey
MOOC1 Iteration 3	Citizen Science: From Soil to Sky	11/2/19-8/3/19	1977	771	305	258	146	-Regenerative practices surveys
MOOC2 Iteration 2	Citizen Science: Sensing the World	18/3/19-5/4/19	857	361	123	164	139	-Insights from learners' comments
MOOC3 Iteration 2	Citizen Science: Living Soils, Growing Food	13/5/19-31/5/19	2,057	967	371	275	170	-Insights from learners' comments

Table 1.2 Overview table of GROW MOOCs, iterations and enrolment statistics.

1.1.5 Insight Workshops

Online and face to face Workshops were used as to kick off Missions whilst Insight Workshops (IWs), a novel engagement, training and innovation method, employed during and at the end of Missions were designed to bring together representative stakeholders with citizens. In these workshops, GROW facilitated the collaboration of citizen scientists and Community Champions with professional scientists (from inside and outside the consortium) to capture and interpret data, and to ideate social and service innovations based on the CO's data and activities.

The IWs were extended beyond the original intention to share insight at the end of Missions, to additionally provide a necessary method for supporting citizens through several of the GROW Framework stages, especially Sensing, Awareness, Innovation. IWs also contributed to Community Building and Scoping stages by bringing people together and identifying new knowledge and data gaps respectively. In the following sections, we describe the different formats and stakeholders involved in the Insight Workshops run to support the Changing Climate and Living Soils Missions.

1.1.5.1 Webinars

As part of the GROW MOOC Programme, the Observatory ran three webinars. These live streamed sessions brought together learners from the MOOCs with educators to discuss insights from the data collected and/or presenting during the courses and have an opportunity to ask questions and share experiences. The webinars were also available for people who had not been involved at that point, they were hosted on the following dates:

- MOOC1 Citizen Science: From Soil to Sky Webinar Programme on 29th June 2018
- MOOC3 Citizen Science: Living Soils, Growing Food on May 3rd, 2018
- MOOC 4 Citizen Science: From Data to Action Webinar as part of GROW Celebrations for World Soils Day on 5th December 20.18

These live sessions were live streamed via Google Hangouts on YouTube, and the recordings made permanently available on the GROW YouTube channel afterwards. See for example a blog post and a video recording of Webinar 1, Citizen Science: Living Soils, Growing Food Webinar recording here: https://medium.com/grow-observatory-blog/grows-first-live-online-discussion-on-your-soil-your-data-e2980da7aeaf.

1.1.5.2 Co-Design Workshops

Designing and building citizen observatories holistically and with multiple stakeholders is a complex and involved process. The GROW Observatory has made a contribution to showcase how the design discipline is well-placed to respond to wicked problems such as droughts, floods and other climate-related hazards that present critical challenges for communities across the world ((Buchanan, 1992, CSDRR, 2019). The literature reveals a lack of user-led approach to the development of climate services (Christel et al, 2017). Instead, scientists and governments rely on research and innovation between science and industry to develop climate services and innovations for early warning systems and decision-making.

In this context, the GROW Observatory has created, tested and iterated a co-design methodology and tool for bringing diverse groups of stakeholders together and facilitate dialogue and the fast generation of CO's, potential innovations and service prototypes.

The tool is composed of a canvas and a set of six categories of cards (examples can be seen in Figure 1.1 and 1.2 below):

- Persona cards
- Place cards
- Data cards
- Critical event cards
- Sustainable Development Goals cards

Figure 1.1 Row 1 - Scenario Cards, Row 2 - Persona Cards, Row 3 - Place Cards

Figure 1.2. Row 1 - Reverse of Data, Scenario and Persona Cards, Row 2 - SGD 13 front, SGD 13 reverse and SGD 6 front

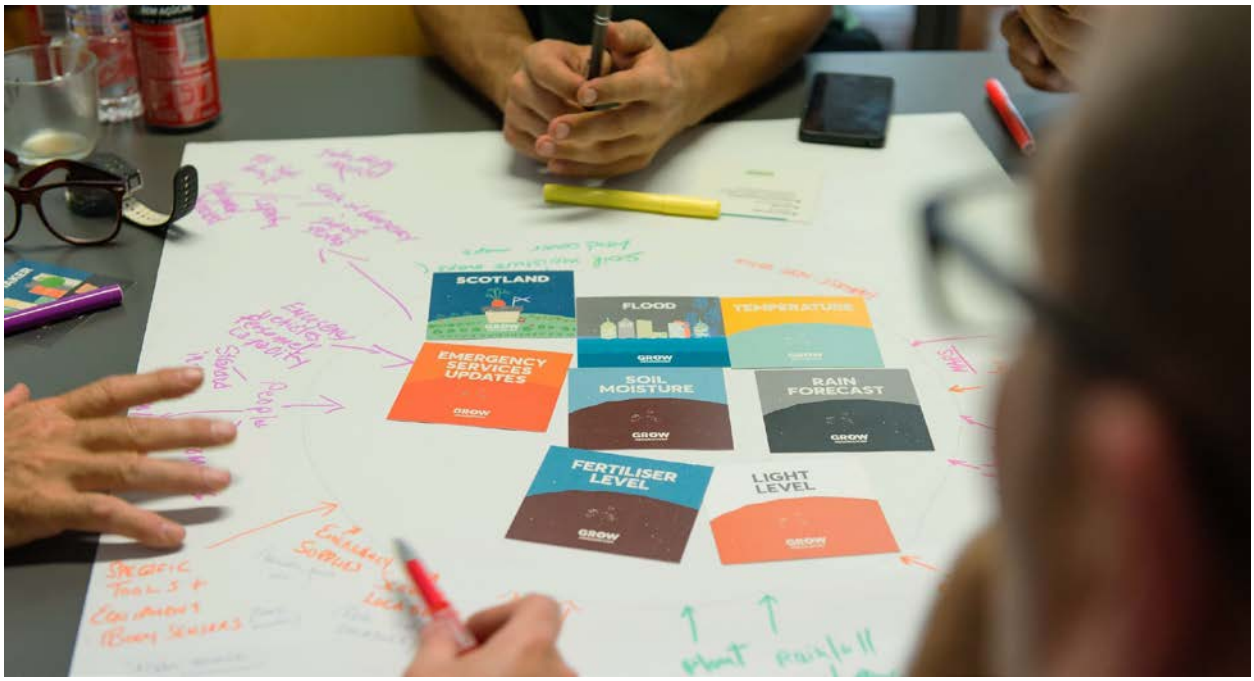


Figure 1.3: Co-Designing a new Observatory, Workshop participants use Climate Scenario (Scotland and Flooding) and Persona cards to map data streams.

The development of the tool and the methodology involved a process of delivery, validation and reiteration with different groups of stakeholders at four different countries and two continents, including:

Designers at Academy for Design Innovation Management (ADIM) in London - 20th June 2019. The session received the ADIM 2019 Top III Workshops Award in London (see conference website: https://designinnovationmanagement.com/adim2019/). A public report from this event including a description of the methodology and examples of session outputs can be accessed here:
https://discovery.dundee.ac.uk/en/publications/design-for-climate-services-a-co-design-approach

Policy-Makers at GROW Policy Workshop in Brussels - 3rd September 2019.
The agenda for this event can be found here: Deliverable 3.5 Observatory Policy Interface report

Citizen Scientists and Community Champions at GROW Insights Workshop in Lisbon - 18th September 2019. A session within the IW tested the tool with GROW participants and external scientists.

Environmental Ministers and Scientists at Transformations Conference in Santiago de Chile - 15th October 2019. A one day workshop introduced to tool to a community who are well versed with emergency events - earthquakes - who non-the-less were keen to consider what CO's could bring to this and other critical climate challenges in S. America.

In all, groups co-designed and named 12 novel Citizen Observatories

1.1.5.3 Community Champions Gatherings

The project recruited of 17 Community Champions in two rounds: April 2018 and May 2019. Regular contact was maintained with Champions by email, social media and regular online meet-ups. In total, 17 monthly Online Meet-Ups took place on the 1st Thursday of each month.

To complement the online interaction, local face to face events, such as this event in Portugal: https://medium.com/grow-observatory-blog/from-austria-to-portugal-via-a-really-interesting-hole-e05e360ee406, were held across GROW Places.

Members of the GROW Places Team, a cross WP working group, attended several of these face to face meet-ups. Additionally, Community Champions Gatherings were held in 2018 and 2019 in Austria and Lisbon respectively. More details can be found later in this deliverable for the 2019 event, and in Deliverable 2.3 for the 2018 Gathering.

1.1.5.4 Final Events in GROW Places

Community led final face to face events in several GROW Places took place throughout October 2019, including the Netherlands, Hungary, Ireland, Greece, Luxemburg, Scotland, Bradford, Croatia 1 & 2 and Poland. These events were designed as devolved Insights Workshops. During the Champions' Gathering in September 2019 the GROW team brief and trained the Champions to use an evaluation canvas (covered in detail in Section 2 of this Deliverable) to report on their own experience of participating in GROW and their GROW Place. Champions were then provided with a set of resources to run their own final face to face meet up in their GROW Place, including a suggested agenda to share GROW insights and results, including open datasets and translated canvas to collate feedback from the local participants. Further details about the objectives of these events can be found in Section 4 "Next steps for GROW Place Communities" in this deliverable. As the evaluation canvas and summaries from these events won't come in until the end of October and beginning of November, the insights will be shared in the final project report.

1.1.5.5 Roadshow Events

Additionally, GROW hosted events open to the public as part of Roadshows. These had a with a focus on dissemination of results and showcasing sensors, outputs, GROW tools, citizen-generated data and impacts:

- *Citizens and Open Data for Sustainable Development* public event focused on Citizens Observatories and the Sustainable Development Goals, held on 7th February 2019 at the Athens Conservatoire; a blog post and a video recording of this event can be found here: https://medium.com/grow-observatory-blog/greece-citizens-and-open-data-for-sustainable-development-event-b7f265a951c9

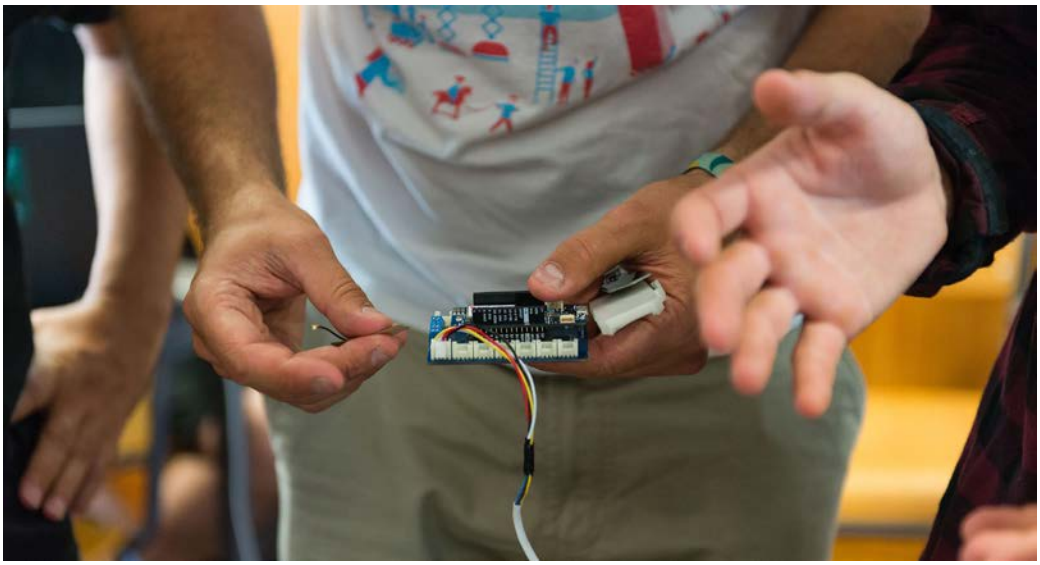
- *GROW Citizens Workshops* organised at GROW Places in Scotland, Greece & Portugal: description and outcomes will be covered in Deliverable 2.5 Evaluation of Citizen Engagement and Active Participation.
- *GROW Policy Workshop (OPI)* in Brussels on 2-3rd Sep 2019: A design thinking approach was applied to have an exchange with policy makers. At this event, a World Cafe session run to discuss the barriers and opportunities that COs present to 1) Policy, 2) Science, 3) Citizens and 4) Technology. The outcomes of this session can be found in Deliverable 2.5 Engagement activities and their impacts on policy development. Insights from this session are detailed in Deliverable 3.5 Observatory Policy Interface report.
- *GROW Impact Hub* in Lisbon - 18th September 2019: The details of this event can be found here: https://www.eventbrite.com/e/grow-observatory-citizens-and-open-data-for-climate-action-tickets-70953631221#

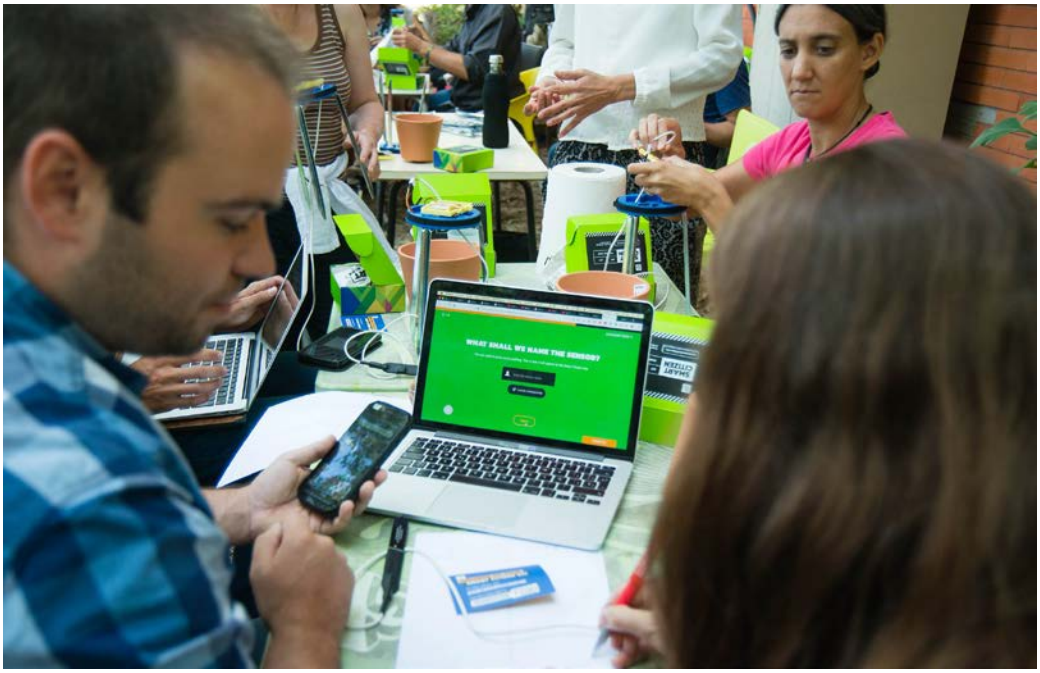
Figure 1.4 GROW Roadshow event in Lisbon at Impact Hub

- *Observing the Environment: Challenges and Opportunities in Citizen Science* event in Brussels, 9 Oct 2019. Brought projects "Citizen Observatories for Environmental Monitoring", funded by H2020 together to showcase their achievements, share best practices, and discuss impact and sustainability. The outputs of this meeting will feed into a report summarising obstacles and recommendations for future programs.

1.1.5.6 DIY Sensor Workshop

As part of the open technology and open data values of the Observatory, GROW was keen to showcase the potential of DIY sensing technology. DIY sensors were presented in detail in MOOC2 Citizen Science: Sensing the World, which run in March 2018 and March 2019. Additionally, a hands-on DIY sensor workshop was run at the Insight Workshop in Lisbon in 2019. Participants were introduced to the Smart Citizen platform; they were provided with all the parts required and guided to build and set up their sensors. In the second part of the session, participants were able to complete the onboarding of the sensors on the Smart Citizen platform, calibrate it, install it and see their data. The details of this session are reported in Deliverable 5.4 *Report on large-scale low-cost sensor platform*. Some photos of participants building their own sensors can be seen below.





2. Changing Climate Mission Evaluation

GROW's Changing Climate Mission described in the Introduction section of this report, effectively began in 2017 with the Over Winter Mission. It had an overarching objective to validate and ground-truth the Copernicus Sentinel-1 satellite soil moisture products, as well as developing a number of soil moisture services built on the sensor data and demonstrate a business case. The Mission supported the deployment and installation of Parrot's Flower Power sensors, a consumer level soil sensor validated by the GROW team, across geographically suitable areas (GROW Places), aiming to provide scientifically valid data for growers, scientists and policy makers. The Mission also provided activities and support to sustain participation, ensure that sensors were maintained and users continued to gather data over the long term.

This section presents the descriptive and exploratory analysis of 20+ Grow Places in 12 EU member-states that took part in the Changing Climate Mission (Figure 2.1).

2.1 GROW Places Network

The GROW Places were selected to fulfil the aims of the Changing Climate Mission by representing different climate and socio-economic conditions across Europe. They and have been led and supported by the local Community Champions and have a dedicated Community Manager (WP2) and cross WP GROW Places team.

The project recruited a network of Community Champions who became core to building GROW's international community. Whilst the concept of Community Champions had been envisaged, having been developed and tested in H2020 Making Sense, the scale of this GROW Mission meant their connection to participants on the ground was vital. Recruitment of GROW Places and CCs was achieved initially in years one and two of the project through kindred networks that aligned with a set of geographic and scientific requirements detailed in Deliverable 5.4 *Report on large-scale low-cost sensor platform.* Recruitment then was extended in year 3 via an open call for participation. All community champions had formal contracts and received payment with delivery milestones. This vital and growing community of communities required a dedicated GROW Community Champions Programme to bring together and generate a Europe-wide community of citizen scientists.

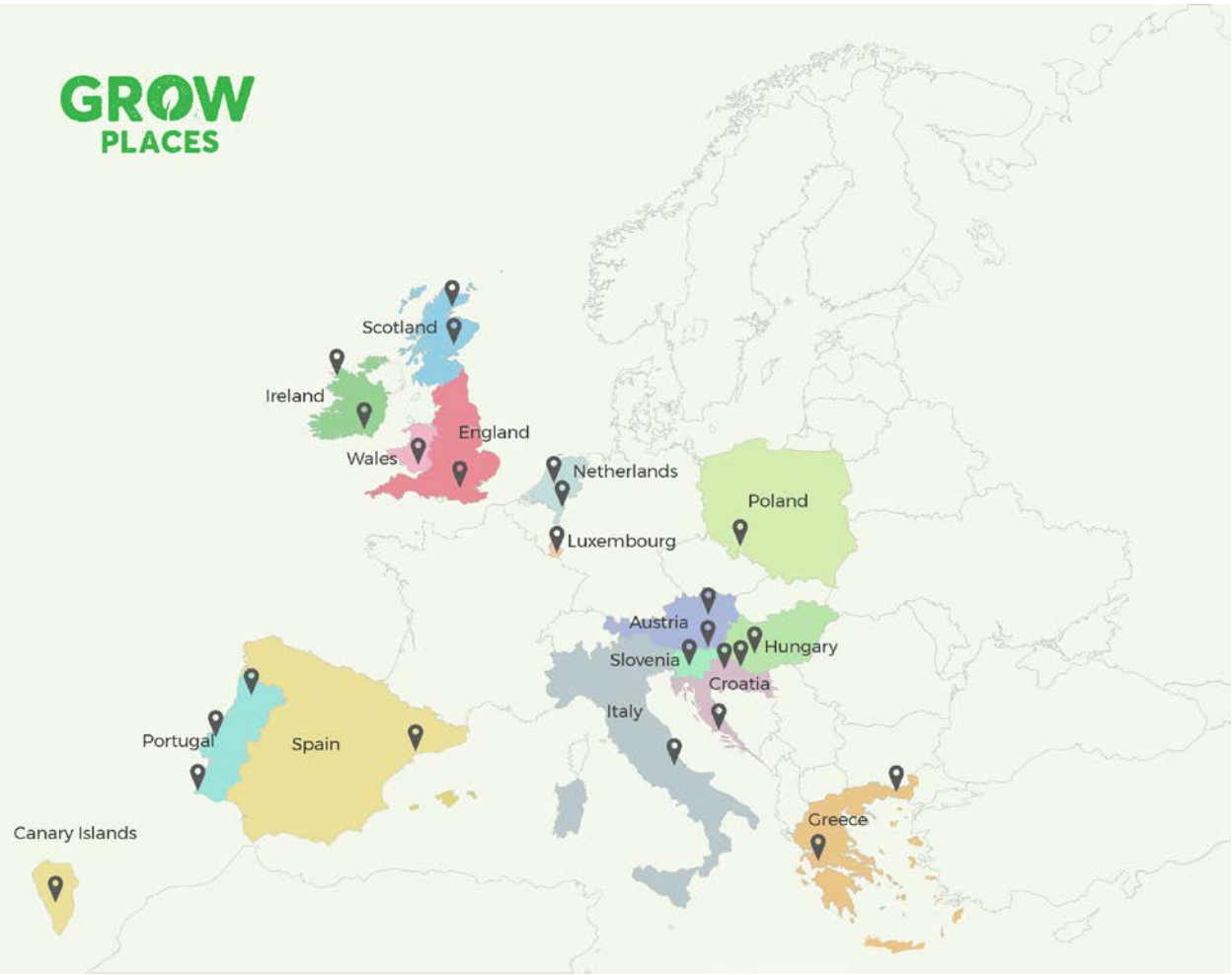


Figure 2.1 GROW Places Network

2.2 Evaluation Approach and Methods

We used a mixed methods approach that benefits from the prior development of theoretical propositions of the innovative GROW framework (in Section 1.2) to describe GROW Places and evaluate the impact of the mission. Two main sources of information are self-reported case studies and evaluation canvases. We also gathered insights through observations at meetups, email exchanges and face-to-face communications with the Community Champions.

A case study template was developed and shared with the Community Champions to draw a complete picture of the GROW Places collaboratively. The template is structured into headings and includes guidance and prompting questions. It gathers their perspectives on the following headings: context and background, rationale, motivations, profile of the sensor users, main findings and impact, limitations and opportunities. The Community Champions completed the

template based on their inside observations and communications with sensor holders (please see Appendix 3 for the Case Study Template)

The evaluation canvas was developed to capture if/how participating in this project has impacted participants' knowledge, practices and interest about soil science, policy and environment. This framework focuses on reflecting ten impact indicators related to this Mission. This visual canvas is based on the GROW Framework and builds on the Place Standard Tool (https://www.placestandard.scot/) which is a tool for assessing the quality of a place and designed in partnership by the Scottish Government, NHS Health Scotland, and Architecture and Design Scotland (see Figure 2.2). (Further details are provided in Section 2.5.1).

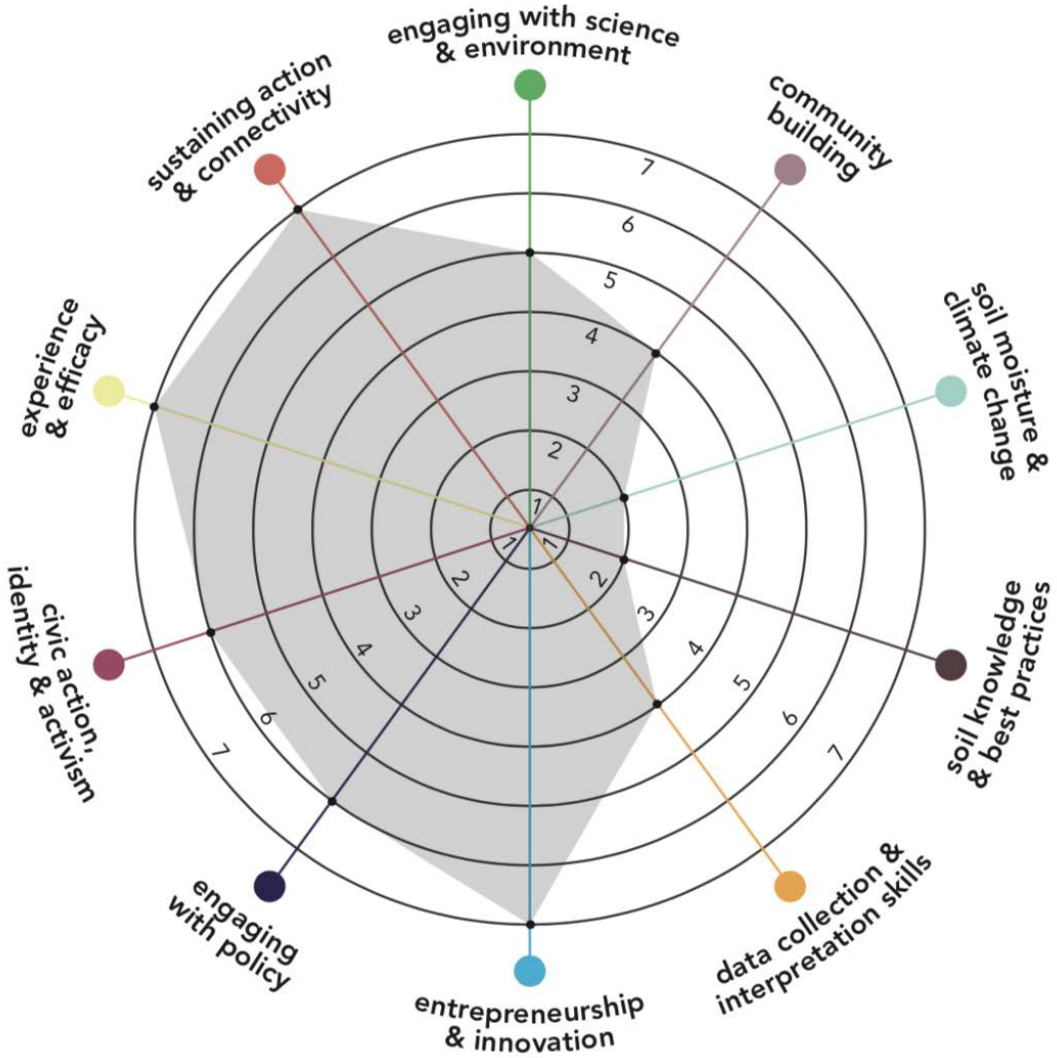


Figure 2.2 Evaluation Canvas example

Some limitations have to be taken into account with regard to the data collection approach. First, it relies on self-report data. Respondents may have painted an overly positive or negative picture about themselves in terms of their motivations, the impact on their knowledge, their attitude towards science independent of the actual change the GROW Observatory develop. Second, the Community Champions completed the tool based on their individual experience, whilst many are able to reflect and represent an overarching viewpoint, it cannot be reliably said to represent the GROW Place collectivity (please see Appendix 4 for the Evaluation Canvas).

2.3 An Overview of GROW Places

This section presents an overview of the GROW Places that participated in the project. Table 2.1 summarises the key information. Some Community Champions (Austria, England, and Wales) could not provide in-depth information in the required time period due to a lack of resources and other pressing priorities. Note, numbers of sensors online at any time does vary from week to week, the numbers provided here are a combination of self-reported where sensor users report and these are validated by live registrations, and numbers accessed from our sensor log when self-reporting was not available. All numbers were accessed in the month of October 2019.

Table 2.1 Overview of Grow Places

GROW Place and Start date	**Community Champion & Organisation**	**No. of sensors installed**	**No. of sensor users**	**The profile of sensor users-organisations**	**No. of gatherings and events**
Austria April 2018	Lebensgut Miteinander & Hendlberghof Community of small scale growers	384	Information not provided by GP	Information not provided by GP	Information not provided by GP
Canary Islands/Spain May 2019	Michal Mos, SME	330	20	1 Local government 3 Wine Makers 1 SME 16 Small organic Permaculture	Information not provided by GP

				farmers	
Croatia 1 (Central) May 2019	James Wardell Grower	384	2	1 Individual grower 1 Forestry Department	1
Croatia 2 (Coastal) May 2019	Tanja Polegubic Salt water, SME	384	16	6 Individuals: Winemakers 6 Organic Farmers (Vegetables and fruits) 1 Research/Community: 1 Forestry department 1 Artist Residency.	1
England1 Leeds May 2019	Cara Wilson PermaCulture UK	768	41	41 Individual growers part of Permaculture UK	11
England2 Bradford May 2019	Lucas Hornby Community non-profit	368	Information not provided by GP	Information not provided by GP	Information not provided by GP
Greece November 2017 September 2019	Calypso Olive Oil Farming SME Kyriaki Chatzisavva Farming SME Georgios Gkaletsas	384 192 192	25	Total users: 25 (20 male + 5 female) of them: 22 are small scale growers (up to 5 hectares) including 7 vine growers/winemakers	10

	Forester SME			1 large olive grower (above 5 hectares) 1 user is the University of Central Greece 1 Government Agency, the Evros Delta National Park	
Hungary November 2017	SZEMművesség Bt SME	1275	148	5 large farmers 130 individual growers 6 educational organisations	9
Italy July 201	Chiara Corbari Politechico di Milano, Department of Civil & Environmental Engineering University	384	37	37 Large farmers	0
Ireland NW April 2018	Joanne Butler Community Gardens Ireland National Community Network non-profit	510	55	20 small scale farmers 35 individual growers	5
Ireland SE April 2018	Dee Sewell, Greenside up	663	45	3 Educational Institutes 1 NGO 41 Individual growers	10
Luxembourg	Centre for	1000	150 (plus	85 Individual	12

April 2018	Ecological Learning Luxembourg Community non-profit		around 65 foresters - under one licence agreement)	growers 23 Small farmers gardens: 7 Large farmers 14 Local authorities 1 Forest and Nature organisation (distributed to about 65 foresters) 3 Schools 2 NGOs 3 Research and other public bodies 3 Wine makers	
Netherlands April 2018	Peter Paree, Farid Makdis ZLTO (Extension Agency)	382 (766 in october)	25	20 medium size commercial farmers 5 small agroforestry farmers	2
Poland May 2019	Noemi Nemes Community non-profit	233	Information not provided by GP	Information not provided by GP	Information not provided by GP
Portugal April 2018	Gil Penha Lopes University of Lisbon, Faculty of Sciences University	1500+	10	1 university 1 community-Eco resort 10 Individual growers	1
Scotland April 2018	Wendy McCombes Forward Coupar Angus Community non-profit	1029	114	7 Large farmers 10 Small holders 96 Individual growers	12
Slovenia	Dr. Borut	264	11	4 small farmers	1

August 2019	Vrščaj, Ana Čebin Agricultural Institute of Slovenia, Department for Agroecology & Natural Resources University			4 large farmers 3 research and educational institutions 2 garden-owners	
Wales May 2019	Alice Grey Grower	175	Information not provided by GP	Information not provided by GP	Information not provided by GP

Table 2.1 Overview of Grow Places

2.3.1 Austria

Austria is mostly under central continental climate zone, influenced by the Atlantic climate. The Austrian Alps, the mountainous regions of Austria (Alpine Climate), however, have much lower temperatures, longer winters and cooler summers. In comparison to Western Alps in Switzerland or France, Austrian Alps are much colder. The average annual temperature in Alpine is 5.1 °C. The average precipitation is 443 mm. Note that flat lands receive much less rain.

There are two GROW Places and four Community Champions in Austria: Tatjana Tupy and Magdalena Resch are leading Lebensgut Miteinander GROW Place, and Volkmar Geiblinger, Nicole Geiblinger are leading Hendlbergof. Tatjana and Magdalena are small scale growers and part of Lebensgut Miteinander, Community Living Project which is on a 60 hectare area around an old monastery in the Austrian Alps. They have been running a Community Supported Agriculture scheme, growing vegetables for the last 4 years and sell food plants in spring (April-June), including seedlings to other food communities, community gardens and Co-ops. They have their own seminar center, which they use to organise meet ups with the local GROW Place community.

Volkmar (film producer and permaculture designer) and Nicole (cook and grower) from Hendlberghof, Chook Mountain Farm, is situated in the Wienerwald at 720m set on a 4.4 hectares. Since 2014, the founders of the farm live and work alongside nature, growing food with responsibility and care for the landa fair and just world. They use permaculture and regenerative practices, and an open-door approach to learning and knowledge sharing. Through farm demonstrations, seminars and community development, they aim to provide an example of a regenerative lifestyle that can be replicated and attainable for all.

2.3.2 Canary Islands

GROW Place Canary Islands Spain is El Hierro, the smallest of the Canary Islands. It is a volcanic island, where Pico de Malpaso is the highest point on the island, 1496 m above sea level. It has varied climate ranging from rom humid subtropical climate to hot semi-arid and tropical desert climate. The areas below 500m elevations are under Mediterranean /subtropical climate zone. The northern part of the Island is much greener and also colder in wintertime. 500m above sea level is covered with subtropical forests with native trees where it is wet and humid. The southern part of the island is covered by volcanic rocks and marked by Canary Pine forest and Sabina Forest and has hotter continental climate. The mean annual precipitation ranges from 150mm in the southern coastal areas to 750 mm in the northern divide.

El Hierro's population is very small, officially ten thousand people registered but around 6000 actually live on the island. The island is recognised by the great biodiversity of plant crops with cultivation of banana, pineapple, passion fruit, cereals, avocado, mango, almonds, grapes and vegetables. The main economic sector is agriculture and nature oriented tourism. Some of the socio-economic problems experienced on the island include that young people move to other Canary Islands or peninsula. The farms are very traditional, lacking of 21' country agriculture technologies. Several land has been left unused in the last three decades, leading degradation and erosion.

2.3.3 Croatia

There are two GROW Places communities in Croatia: the coastal (Dalmatia) and central Croatia (Varoška lug) regions. The Coastal Croatia GROW Place is stretching across the inland, coast and islands of Dalmatia. The area has a long history of agriculture - as a main source of income and certain branches are symbols of Dalmatia. However, it is estimated 50% of the farming land now remains unused. The main activity has been olive and grape growing, sheep breeding and fruit growing. In some areas, essential oil production for the beauty sector is on the rise.

Olive growing has been a traditional activity in this area since ancient times. It has seen a resurgence in recent decades, with many new groves on privately held land being planted as a side endeavour, and mostly for personal use but also for sale. Autochthonous grape varieties and the marasca cherry thrive in the specific soil and climatic conditions. The majority of farms are smallholder plots, with a decline in uptake from young farmers and a depopulation trend in rural areas of Dalmatia. Factors such as the lure of higher paid work outside Croatia and the rise in tourism has seen a shift to many opting to leave the country or enter tourism instead. Agricultural tourism, which has long thrived in the Istrian area (famous for truffles and close to Austria and Italy), is now gaining strong momentum in Dalmatia. Wine tasting tours, rural farms with restaurants and value add tourism souvenir products (such as lavender bags, soaps, beauty products, candied fruits and traditional sugared almonds) can be seen along the coast. The areas chosen for our Grow Place are renowned for their produce and include: The Peljesac wine region, Kastela - the home of the original Zinfandel, the largest marasca cherry plantation in Croatia, lavender and olives on Hvar island and fruit, grape and olives in the Zadar region on Island Iz, Bibinje and Vrana Lake.

Tanja Polegubic is leading the Coastal Croatia GROW Place and is the founder of creative hub Saltwater Workspace, an environmentally focused women-led community. This business is built on networking, meaningful work, and change-making. They support each other with knowledge exchange, workshops, and projects to support business, visitors, and locals.

Many of the GROW participants in Dalmatia have expressed a lack of connection, knowledge sharing, awareness of funding and improving growing methods and thus there is a strong need for a network - a GROW Community. Anecdotally, the notion of “cooperatives” has negative connotations due to the way this model was imposed during the Communist era. Further, there are cost and time prohibitive entry barriers to add technology and the use of data to farming practices.

There are complementary sectors in Croatia which are strong, such as IT startups, tourism and robotics. Joining GROW is considered a way to bring together a wider community across Dalmatia and build the potential of combining new tools and methods, building on the resources already available in Croatia.

The Grow Place Central Croatia is the area of Varoška lug that lies southwest of Vrbovec. The total area is 811.39 ha, and the area was protected in 1982. In summer, the soil dries out. Precipitation replaces soil moisture. James Wardell, the community champion in the central Croatia, has a small-scale cattle and permaculture ranch and the Varoška lug forest is next to where he lives. He is the only one deploying sensors (384) and collecting data. The sensors are placed in a local forest. The forest is mostly beech, hornbeam and oak. The river Glogovnica runs through the forest. The forest is managed by the state forestry department Hrvatske šume. In general, the department does not allow private enterprise to access their resources unless it is under exceptional conditions, James through his Hrvatske šume contact made sensing activities in the forest possible. According to James, although the other farmers recognised the sustainable benefits of this project, they did not want to commit their time unless there are financial incentives available.

> *“Local farmers were not interested in helping unless they received a financial incentive. There is huge potential for developing Citizen Observatories in Croatia and former Yugoslav countries. People see that such things can bring sustainable benefits. They always need to see that it has worked in other countries before they commit.” James, Central Croatia*

2.3.4 England

GROW Place England is Bradford, a city in West Yorkshire built at the junction of three valleys in the eastern moorland region of the South Pennines. In general, the UK climate is temperate and prone to mild moist weather in the west, drier and hotter in the south east, colder and wetter in the north. Bradford experiences limited seasonal temperature changes, the climate is warm and mild. The Köppen Climate Classification subtype for this climate is "Cfb" (Marine West Coast Climate/Oceanic climate). It received significant rainfall throughout the year. The average annual temperature in Bradford is 9.2 °C. The average amount of annual precipitation is 840 mm.

Vicente Ramirez Garcia, GROW Place Community Champion from Bradford, came to the UK from Mexico in 2004. He is one of the co-founders of Grow Bradford. They aim to document, connect and promote local food and growing activity, on- and off-line, in and around Bradford.

GROW is also partnered with the Permaculture Association Britain (PAB) that has a diverse range of people, mixed amateur and professional gardeners and land workers with a range of incomes.
The PAB aims to generate practical solutions to current environmental and social justice issues and promote a sustainable lifestyle. Association members are hoping to share results and observations across the country and to find a way of working together after the project end. The Association has an ARCGIS license and focused on measuring differences between permaculture and non-permaculture sites, and adding to the scientific evidence base for permaculture practice, which is lacking.

2.3.5 Greece


GROW
FOOD

GROW Place Alexandroupoli, the capital of the Evros regional unit, is home to the ancient olive grove of Makri, the National Park of Dadia forests and the wetlands of the Evros Delta National Park. It is estimated that seventy thousand inhabitants live in urban, suburban and scattered settlements. Alexandroupoli has hilly, coastal, and urban/peri-urban arelands, with clay-sandy soil. The district is recognised by cultivation of olives, sunflower, mulberries, legumes and fruits. Due to its dry Mediterranean climate conditions, agricultural land is widely irrigated causing severe pressures on wetlands and accelerating phenomena such as erosion and soil salinity.

Although Alexandroupoli is a major international border in Europe, a strategic military base and a growing fossil fuel trade node, it experiences shrinking demographics and high unemployment. Growers in the area can be described as small sized, family owned, growers and dispersed units. GROW partnered with CALYPSO, a family-owned olive grove. They produce premium quality Single Varietal Extra Virgin Olive Oil. Valorising the ancient variety of Makri, they are the first organic producers in the region, adopting agroecological practices since 2011. Mission Lead, Pavlos Georgiadis, (Ethnobotanist. Sustainable Development Consultant. Agrifood Entrepreneur), is the fourth-generation passionate olive grower and owner of Calypso.
Alexandroupoli, faces proportionally more extreme temperatures and drier conditions in comparison to other GROW Places. The impact of climate change is severe. Pavlos from Calypso points out,

"in September 2018, we had an average temperature of 12 degrees higher than previous years, which led to the multiplication of a fungus that eventually caused a 70% loss in our production".

Future climate will challenge fragile small sized growers in Greece and the food industry in general. GROW Climate Change Mission will increase the region's adaptive capacity through better understanding of temperature thresholds, soil moisture, growing degree days, drought for the varieties grown and the adoption of new cultivation techniques and strategies.

GROW Place Ireland NW is based in Donegal, the far NW reach of Europe looking out at the Atlantic Coast. County Donegal is a largely Irish-speaking region bordering the Atlantic Ocean in northwestern Ireland. It is made up of castles, rugged coastline and mountains such as the quartzite Mount Errigal. Glenveagh National Park, once a private estate, encompasses forests, lakes and bogland in the Derryveagh Mountains. Donegal has a vibrant community garden scene with over 30 community gardens spreading over the county. The population in 2016 reached 159,192.

GROW Place Ireland SE is based across several counties including Carlow, Kilkenny, Waterford, Tipperary, Laois and Wexford. It is primarily made up of farmland, tillage and beef primarily. The South-East region (excluding Laois and Tipperary which head into the Midlands) spans 7,198 km2, 10.2% of the total area of the state and according to the 2016 census had a population of 422,062

Joanne Butler and Dee Sewell are the GROW Community Champions in Ireland. In the North West, Joanne runs the social enterprise OURganic Gardens, facilitates food growing classes and holds sustainability workshops throughout the year. In the South Rast, Dee Sewell, MCI Horticulture and transformative community educator, is managing owner of Greenside Up a provider of horticultural and environmental education that supports and promotes social inclusion, wellness and community development.

2.3.6 Italy

The GROW Place in Italy was recently set up in July 2019. Based in the Puglia region, the Sud Fortore district, located in Southern Italy, bordering the Apennines on the west and Gargano Promontory on the east side. The area is led by the Capitanata Irrigation Consortium (http://www.bonificacapitanata.it/) and is about 65'000 hectares of which only 45% is irrigated through the Consortium water distribution network (56700 ha), while the remaining areas are irrigated

with private wells. The role of irrigation is crucial, in fact the mean irrigation volume for the irrigation season from April to October is about 600 mm, while the seasonal rainfall precipitation amount to 150 mm. Daily irrigation volumes measured in the main aqueduct are available from 2013 to 2018 and are provided by the Capitanata Irrigation consortium.

The Sud Fortore district is an intensive cultivation area, mainly devoted to durum wheat and tomatoes during the spring-summer season and fresh vegetables (sown in late summer and harvested October-February).
With the sensor measurements, the farming community will be able to better control the irrigation water needs with a better timing and quantity over different water demanding crops, in combination with other applications of irrigation water needs forecast (e.g. www.sim.polimi.it). Large farmers are the main sensor holders, interested in monitoring irrigation water uses in order to plan water saving activities. Even though this Grow Place has been running for only four months, the irrigation consortium managing the water distribution has shown interest in monitoring water use over large areas. In addition, Politecnico di Milano, which is involved with its real-time hydrology group, is interested in using soil moisture data for research activities in the field of irrigation management using remote sensing data and hydrological modelling.

2.3.7Luxembourg

The Luxembourg GROW Place covers the whole of the Grand-Duchy of Luxembourg. It has an area of 2.586 square kilometers, maximal length N to S is 82 km and 57 km to West. Luxembourg comprises four biogeographical regions with different geologies, soils, vegetation types, land uses and even climate and the altitude ranges from 130 to 560m above sea level. The annual precipitation is about 800 mm. Luxembourg's climate is sub Atlantic with humid and cold tendencies; however, in recent years it has started to carry the characteristic of continental climates with harsher winters and more pronounced temperature differences between seasons. Mean annual temperature has been around 9 degrees and varies between 0 in January and 18 degrees in July, with an exceptionally hot summer in 2019.

Regarding vegetation, forests cover about 90.000 ha which represents over one third of the countries surface area and public forests are managed by the administration of forest and nature. 46 % of Luxembourg's forests are publicly owned, and 54% are privately owned. Other important land use is agriculture: pastures, hay meadows, crop fields (wheat, corn, oilseed and rape).

In Luxembourg, GROW partnered with the Centre for Ecological Learning (CELL, www.cell.lu), founded in 2010 and launched in 2011. It is a non-profit organization that provides an experimental space for thinking, researching, disseminating and practicing post-carbon lifestyles and regenerative culture. The Community Champions, Tania Walish is an environmental Scientist and Karine Paris is a geographer, agroecology advocate and urban gardener.

2.3.8 Netherlands

GROW Place Netherlands is the area of 's-Hertogenbosch in South Netherlands. Climate in this area is temperate, and there is a significant amount of rainfall all year-round, the average rainfall is 786 mm. The KöppenClimate Classification subtype for this climate is "Cfb". (Marine West Coast Climate/Oceanic climate). The average annual temperature is 9.4 °C. The type of soil ranges from sandy soils at 'higher' +20m altitudes to clay at below sea surface. Sandy soils are poor and dry therefore are well fertilized and irrigated. Clay soils are rich but cannot be irrigated because groundwater is often salty. Severe drought for the last two years is a big challenge for both types of soil.

GROW is partnered with the Southern Agriculture and Horticulture Organization (ZLTO) which represents the interests of around 15,000 farmers and growers in South Netherlands. https://www.zlto.nl/english. ZLTO supports green

entrepreneurs in their daily operational business, connecting them to other sectors and organizations to create new opportunities for sustainable economic growth and social welfare. It also builds better connections between farmers and consumers and people who love the countryside. ZLTO participates and invests in strategic activities and innovative projects within the food and agriculture sector, while forging partnerships with other sectors and social organizations in order to create added.

2.3.9 Portugal

GROW Place Portugal extends in two Priority Areas: one in the Herdade da Ribeira (research station managed by ce3c-Fcul), near Grandola in Alentejo and one at the regenerative project of the Vale da Lama, near Lagos in the Algarve, including the inspiring Quinta do Vale da Lama.

In general terms, the areas have a Mediterranean-type climate characterised by hot and dry summers with the mean annual temperature is around 16 C. Most of the rainfall is concentrated between October and April. Irrigation is essential all year round, especially in spring and summer due to the high climatic demand and the absence of precipitation as the mean annual precipitation is 700 mm.

At Vale da Lama, Quinta do Vale da Lama is a 43 hectares farm in the western Algarve, is an eco-resort, providing farm-based experiences and trainings that empower individuals of all ages and backgrounds to create positive social and ecological impact by living in a regenerative way. The whole farm is a permaculture and regenerative agriculture project that works together with nature. Its founders experiment several ways of growing food, working with biodiversity of plants and animals, redesigning the farm to become a resilient landscape. Their intention is to establish and maintain permanent systems that bring abundance for this and future generations (https://www.valedalama.net/en/sobre-nos/). They aim at monitoring soil regeneration across decades deploying more than 200 sensors. There are also individuals, families and small farmers who monitor their lands deploying nearly 10 sensors each.

At Herdade da Ribeira Abaixo, near Grandola in Alentejo, is led by a research station, ce3c-Fcul (https://ciencias.ulisboa.pt/en/ce3c-centre-ecology-evolution-and-environmental-changes). Gil Penha-Lopes is the Community Champion from the Faculty of Sciences at the University of Lisbon. Their main priority is conducting research deploying more than 1000 sensors.

Socio economically speaking, these GROW communities are dependent on their lands and agricultural systems. It is important to safeguard rural diversification, invest in the future, creating new employment possibilities in the GROW Places.

2.3.10 Poland

The Polish GROW Place is in the southwest of Poland, close to Studety mountains. The area has continental climate, experiencing vastly cold winters, often below freezing, and warm summers. The average annual precipitation for the whole country is 600 mm. Summer is the rainiest season, thunderstorms may occur in the afternoon, more frequently near the mountains and more so in the southern parts. Growing season is also 40 days longer in the South West than in the northeast.

Noemi Nemes and her team from Deep Roots, an ecological farm, are leading the GROW Place in Poland. They have backgrounds in ecological economics, organic agriculture, and horticulture, respectively and have completed courses and long training sessions applied permaculture, appropriate technologies, and holistic management. Their ecological farm at the foot of the Sudety mountains is a

regenerative community farm where five families will live together to attend the land organized as a land trust – of which a main goal is ecological restoration.

2.3.11 Scotland

The Scottish GROW Place is predominantly in Tayside and the Central belt of Scotland. This area is classed as Lowland Scotland (as opposed to the Scottish Highlands and Islands). The majority of the Scottish GROW area is rural or semirural, around small to medium towns such as Dundee, Perth, Coupar Angus, St Andrews, with a few sensors deployed in Edinburgh and Glasgow. While there are no significant mountains in this area there are ranges of hills e.g. the Sidlaw Hills (3-500m) and the Ochil Hills (5-700m). Most land in the area outside towns and villages has been improved and is used for agricultural purposes. The area is relatively prosperous (in Scottish terms), although there are areas of significant deprivation in many of the medium and large towns.

Wendy McCombes leads the GROW Place Scotland and runs growing and cooking projects of Forward Coupar Angus, including the community gardens. She focuses on opportunities to improve the economic aspect of the town's development for people of all ages through education, training and volunteering initiatives which help increase people's employability and build a foundation for the future. Forward Coupar Angus is a community-led development trust founded to improve the economic, environmental and social sustainability of Coupar Angus and its immediate surrounding area. Its mission is to transform Coupar Angus into a

buzzing and safe modern town that all residents and especially families and children enjoy being part of. A town that strives to create opportunities for a better social and working environment, while at the same time aiming to fight climate change by reducing carbon dioxide emissions in the community.

2.3.12 Slovenia

In the Grow Place AIS Ljubljana, the climate is mostly sub-Mediterranean, influenced by westerly winds and Alpine – Dinaric barrier with 900 -1.000 mm precipitation/year which rise up to 3500 mm/year on some parts and dropping to 800 mm at the Pannonian basin. Water balance of Slovenia is highly positive (Pavg = 1.500 mm; ETPavg=750 mm). 59 % of all water input (90 % as precipitation, 10 % as inflow) leaves Slovenia as a runoff. Most of the Slovenian territory is covered with forests (58 % in 2017); Slovenia is the third most forested country in Europe, right after Finland and Sweden.

The Community Champions, Dr. Borut Vrščaj and Ana Čebin who are part of the Department of Agricultural Ecology and Natural Resources (DAENR), aim to improve the use of agricultural natural resources, which is why micro-location data on the water regime are very useful. The Grow Place was set up in July 2019, and the sensors have been deployed on different soil types with different land uses, in irrigated and non-irrigated areas. The data can also be used in some of the various projects that DAENR is currently working on. Although there are no concrete conclusions to reach as the place has been set up recently, the initial interest is very strong.

> *“The GROW project has been very successful in Slovenia. Everyone who found out about it wanted to get involved immediately. Because there was so much interest and few sensors, we tried to distribute them as evenly as possible. Many people learned about the project from friends who had already participated*
> *We believe that the project was well designed and offers a lot to the sensor users in return for the data. We have not yet encountered a major obstacle. We still have a lot of work to do and very little time, but we are very committed and optimistic about the data” Ana, Slovenia*

2.3.13 Wales

Alice Grey is leading the GROW Place in Wales. Alice is part of a small community farm in North West Wales, Snowdonia. The farm is on a thin strip of land between the mountains and the sea, gently sloping southwards to the Seiont River. They currently provide around 120 families with fresh organic vegetables on a weekly basis via their Community Supported Agriculture (CSA) scheme, as well as three local shops and an array of caterers.

Snowdonia is mountainous region in the in North Wales, experiences a temperate maritime climate. Like the vast majority of the UK, the weather is unpredictable, it is mild, typically warm rather than hot summers (average temperature high: 12.91°C) and cool to cold winters (average temperature low: 7.25°C).

2.4 Understanding Participation

In order to understand the complexity of participation in GROW we have considered participants views on environmental concerns, their ability and related motivation to act in a motivation mapping exercise conducted by WP1 in 2017 and 2018 prior to the replication and amplification open call to extend Grow Places in 2019. This aided to understand CCs' motivations and inform the mission to help address the environmental concern in each place, as well as to better communicate their stories and values. Motivations for taking part in the Mission

from the first GPs that had joined by September 2018 were reported in Deliverable 2.4 *GROW Communities Champion Programme*. More information about GPs' motivations to join the Changing Climate Mission can also be found in their GROW Medium blog posts: https://medium.com/grow-observatory-blog. Mapping Motivations alongside consideration of the specific geographic, social and political context (in section 2.3) are important dimensions of good governance.

2.4.1 Profiling Organisations, Community Champions and Sensor holders

In the following section, we present the results of an analysis of organisations, CC's and sensor holders, as well as reports of impact from participants in the Changing Climate Mission.

GROW Missions (WP1) partnered with Community Champions to lead the GROW Places, which are presented by organisations categorised as community networks, communities, SMEs, extension agencies and research and educational institutions. The breakdown of the GP organisations can be seen in Figure 2.3

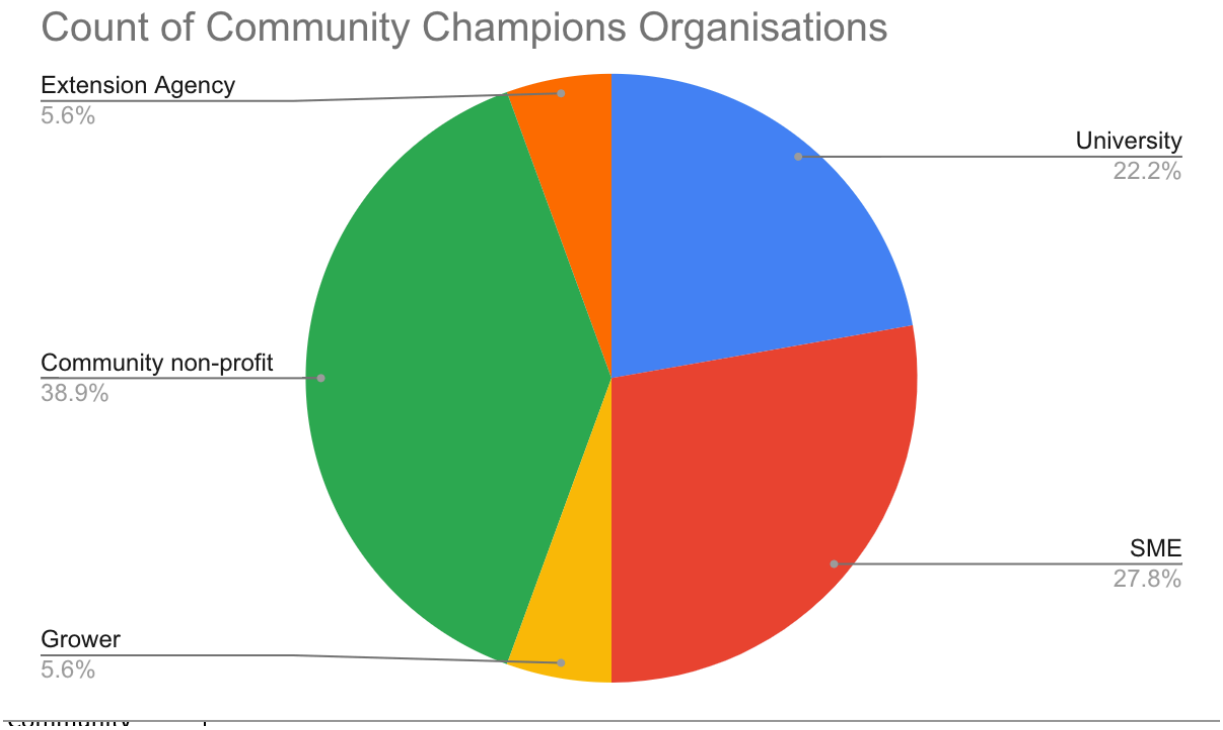


Figure 2.3 Breakdown of Community Champion Organisations

The majority of the Community Champions are part of non-profit

Communities (38.9) and followed by SMEs (27.8%) and universities (22.2%). This matches the GROW (Observatory) framework/methodology that promotes community building, data innovation, business case impact. The Changing Climate Mission is designed to be mutually beneficial between Community Champions, their organisations, and the GROW Observatory. The Community Champions' involvement and networks have played a key role in the success of the Climate Change Mission while participation in an EU-wide project provided visibility to the GROW Places and the organisations of the Community Champions (mentioned by Ireland, England, Luxembourg, Greece GPs).

> *"As a national organisation which is voluntary led we were keen to get involved in this project as we felt it gave us a role to play in a European project. As part of Community Gardens Ireland and Donegal Community Garden Network, the GROW project really helped to boost our projects through a wider audience. We noticed the age profile in interested parties varied from young to old."*

Similarly, Cara from Permaculture Association Britain noted that:

> *"It (participation in the project) has helped to validate permaculture to the most scientific sections of our network."*

Through using the Community Champions' network and other sources of media, GROW Observatory has engaged with a wide range of participants. Tanja from Croatia points out the importance of their network.

> *"Getting support and participation from users was easy. Out of 20 invited to participate, only 4 turned down the opportunity. We consider they either did not understand or care about the goals, or were time-poor. After some media coverage in a newspaper, we were contacted by additional people - but this was through someone who knew one of the growers or Community Champion. It could be stated for Dalmatia, if they are not personally connected or invited, it still appears to be a foreign concept and not something many would volunteer for."*

The Community Champions who are also part of a university have an additional interest in participating in this project. Most of them used the data to complement their individual research or they used to develop new ideas. Slovenia, Italy, Hungary, Austria and Portugal GROW Places) as the quote below reflects:

> *"I'm Chiara Corbari, a researcher in water science engineering at Politecnico di Milano, interested in parsimonious irrigation with a high technological information, using satellite, drones, numerical modelling but with a strong connection with ground information. Through GROW I am able to combine these research*

instruments with several soil moisture data to better control irrigation water use with a better timing and quantity over different water demanding crops".

This lead to several data innovations which are presented in the Data Innovations section below (Section number will be added).

As seen in Figure 2.4, there is a variety of sensor holders, including small to large sized commercial growers, private enterprises, government agencies and NGOs, education and research institutions and individual growers. The majority of participants are Individual growers (442, 58.5% of all participants). This group includes hobby growers, small allotment holders and gardeners. They are predominantly non-commercial growers some of which may grow a significant amount for self-consumption. The associates of communities or growing organisations, such as Permaculture Association Britain are also grouped under individual growers. Commercial growers and private enterprises participated in the mission, making the commercial sector in total of 27% with 204 sensor holders. Private enterprises (14 participants) comprise predominantly wine makers (12 participants). Small commercial growers (124 participants) involve small scale farmers, family farms, smallholder farmers who are part of a Community Supported Agriculture scheme. In this group, there are also small-scale winemakers (19 participants). Amongst these small commercial growers, we see traditional growers as well as growers following sustainable growing methodologies such as agroforestry and permaculture. Public sector is also well represented in the mission by government agencies, NGOs and education and research institutions (14.2% with 107 participants). Forestry Departments (67 participants) are the largest number of sensors in this group. Education and research institutions include schools, colleges, universities and research centres (2.8%).

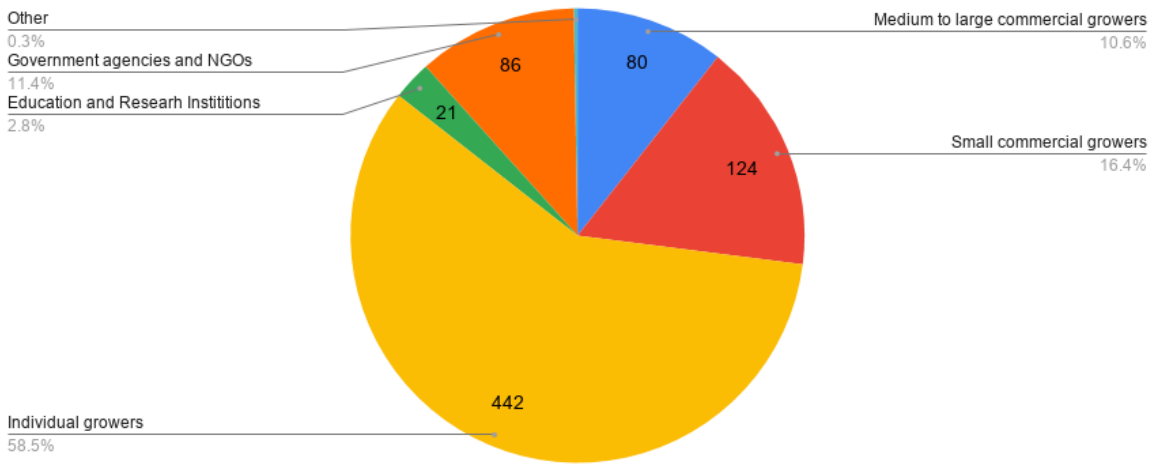


Figure 2.4 Profile of Participants

Amongst these sensor holders, there are also ‘superusers’ who deploy a large number of sensors and have well-defined motivations to monitor their soil and collect data. For example, a scientist from Ireland SW has deployed 60 sensors and is helping farmers convert to organic methods.

Walt Ludwick, a superuser from Portugal, has deployed over 200 sensors around his 43ha farm because he is interested in understanding the farm ecology and desertification in his land. He has designed a number of experiments with the local Community Champion, Gil, and placed sensors accordingly. He placed most of the sensors in a grid-pattern specified by GROW Observatory, and others placed in strategic test control pairs, to measure the relative effectiveness of different patterns of practices. The aim of the experiments is to observe the rate of soil desiccation in the wake of hydration events such as rain or irrigation. In addition, he developed a data dashboard (in RStudio: Shiny environment) to facilitate comparison of values for select variables / sensors/ time periods, to learn much about the different microclimates (both natural and designed) around his farm, and how soil moisture/ temperature/ light values vary with changing conditions over time. Figure 2.5 is a screenshot of the data dashboard.

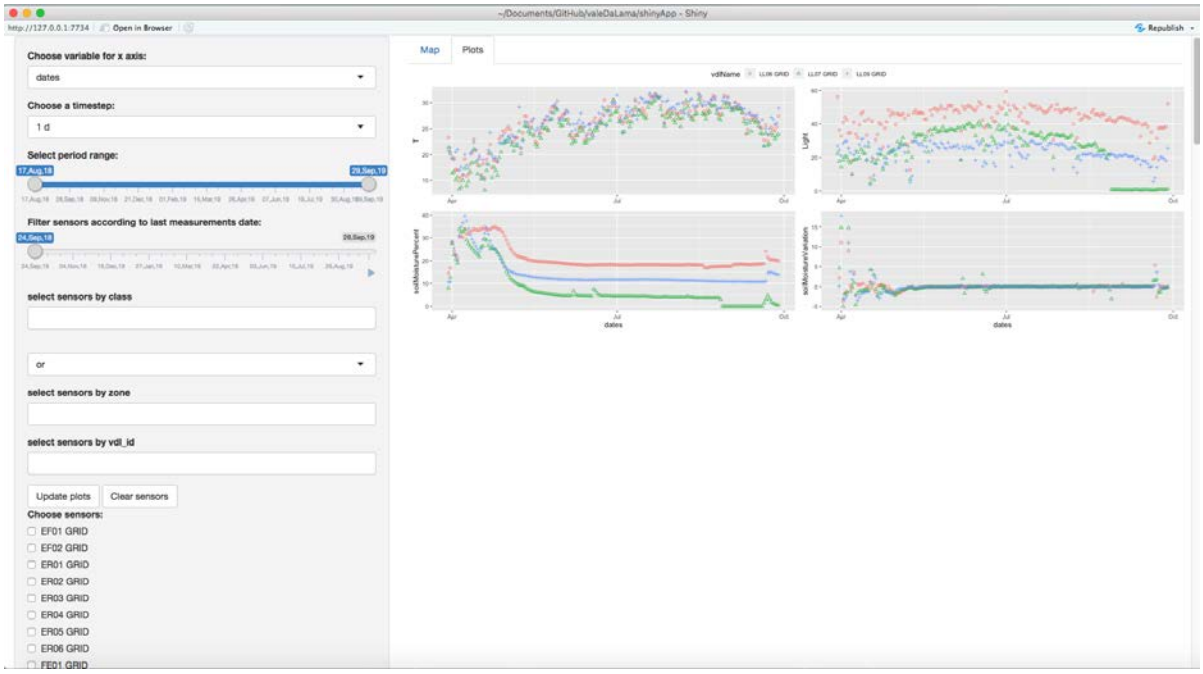


Figure 2.5 A screenshot of the data dashboard developed by Walt Ludwick (in RStudio: Shiny environment)

According to the self-reported data by the Community Champions, there are 754 sensor users and 11769 sensors installed. As the Community Champions from Wales, Austria, Bradford and Poland were not able to return their numbers within the required time, the participants from these communities are not included in the total number of participants. Figure 2.6 demonstrates the number of sensors/users ratio by country. The scatter diagram below (Figure 2.7) presents sensors/ users ratio in the y axis and the number of users in the x axis and it is organised by country. We can infer four typologies with respect to sensor usage. One is "many sensors, many users", placed at the right side of the graph. Luxembourg has the largest number of sensor participants (215) as well as sensors (1000). At the opposite side, on top left, we can see another typology, "many sensors, few users". In Portugal, for instance, the sensor/user ratio is very high:1500 sensors/10 participants. One reason for this is the Community Champion, based at the Lisbon University, who has installed approximately 1000 sensors. In addition, the abovementioned superuser in Portugal installed 220 sensors, who work in close collaboration with the Community Champion. At the corner below we have the "few sensors, few users" typology; most of the GROW Places are in this cluster. Ireland, Scotland and Hungary, which have many participants and a large number of sensors, are placed in low mid part of the diagram.

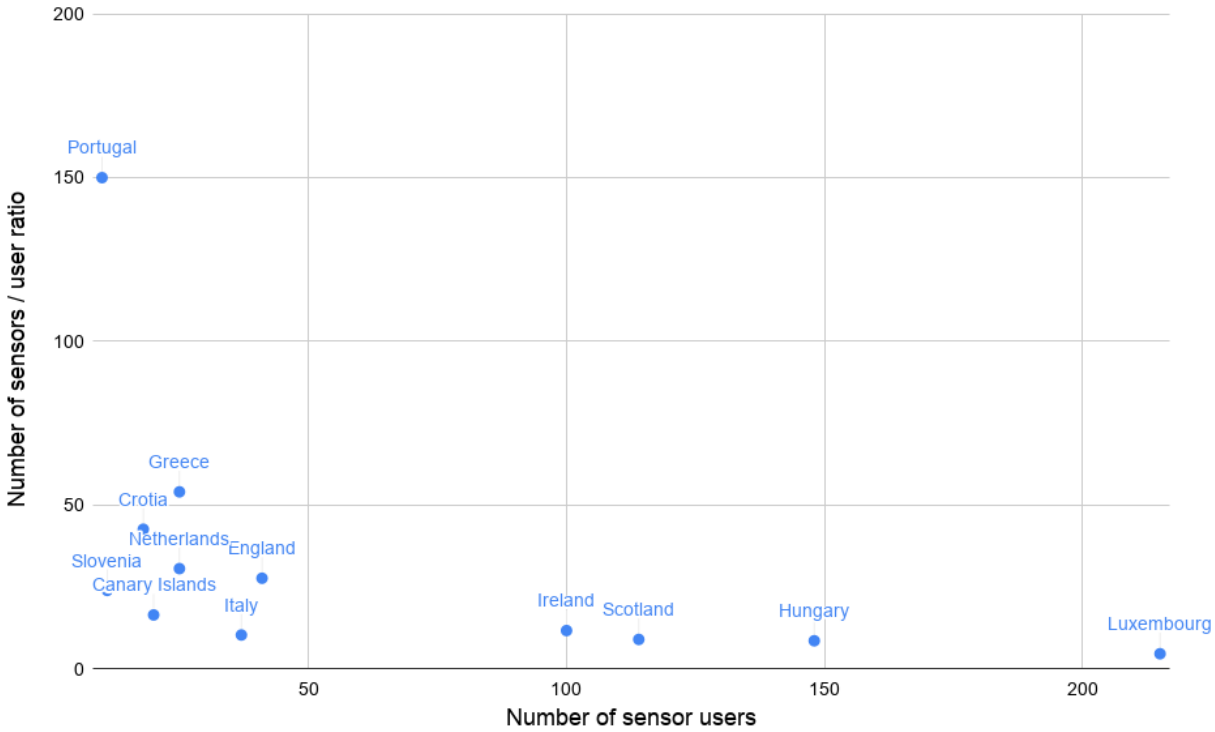


Figure 2.6 Number of sensors/users ratio by Country

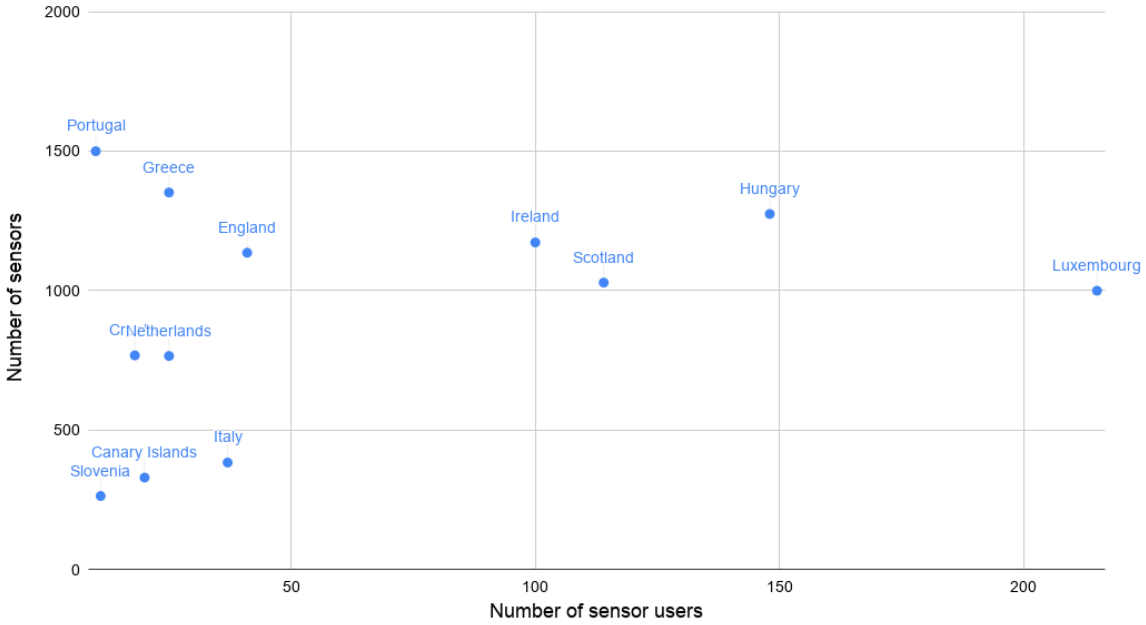


Figure 2.7 Number of sensors and number of sensor users by country

2.5 Evaluating the impact

2.5.1 Results of the evaluation canvas

15 Community Champions and three Superusers completed the canvas towards in September 2019, to measure the impacts participating in the project has had in their communities and organisations. The canvas gathers both qualitative and quantitative information about their participation in the project and focuses on 10 indicators (see table 2.2 below). The majority of the participants (16 out of 18) completed the canvas in pairs at a group session during an Insights Workshop in Lisbon, and discussed each of the indicators and how they played out in their local context. The other two Community Champions who were not present at the event completed the canvas remotely and sent it by email. They rated the indicators on a scale from 1 to 7, where 1 means the project has created the lowest impact and 7 means the highest impact, and recorded their rating on the compass diagram. They also noted the reasons for their rating on a provided space in the evaluation canvas. Their notes show that the Community Champions completed the canvas on their behalf, not for the GROW Place Community.

The indicators are listed below along with the prompting questions in Table 2.2. The indicators are placed on the diagram clockwise starting from 12, please see

Figure 2.8 as an example. To analyse the data we have digitised the information provided on the canvas along with the case study template. Qlik Sense and Microsoft Excel were used to analyse and visualise the information.

Impact Indicators	**Explanatory Prompting Questions**
Engaging with science and environment	● Has participating in GROW Observatory motivated you to learn and use science? ● To what extent have you become interested in and excited about facts, explanations and models related to science and environment?
Community building	● How has participating in GROW Observatory enhanced your community? ● To what extent has GROW strengthen the communication and networks in your community?
Soil moisture & climate change	● How has participating in GROW Observatory contributed to improving your understanding soil moisture and climate change?
Soil Knowledge & best practices	● How has participating in GROW Observatory motivated you to learn and use science? ● Have you learned more about ecological growing practices? (eg. regenerative agriculture, agroecology, permaculture)
Data collection & interpretation skills	● How have your data collection and interpretation skills improved as a result of participating in GROW Observatory?
Entrepreneurship & innovation	● To what extent has participating in GROW Observatory fostered innovative and entrepreneurial approaches? ● Have you identified any new areas where the sensor data can be used innovatively?
Engaging with policy	● Have you had any interactions with policy makers? eg. visits from policy makers, writing a letter to your local council. ● Have you identified local policy problems the sensor data can help solve?
Civic action,	● To what extent has participating in GROW Observatory

identity, & activism	contributed to your identity as someone who knows about, uses, and sometimes contributes to science? ● Do you consider yourself as an active citizen?
Experience & efficacy	● How has participating in GROW Observatory inspired and energised you? ● To what extent is the value created worth the time and effort you spent in this project?
Sustaining action & connectivity	● How likely are you going to carry on recording soil moisture and associated data after the project ends? ● How likely are you going to stay in contact with your GROW community?

Table 2.2 Indicators and prompting questions

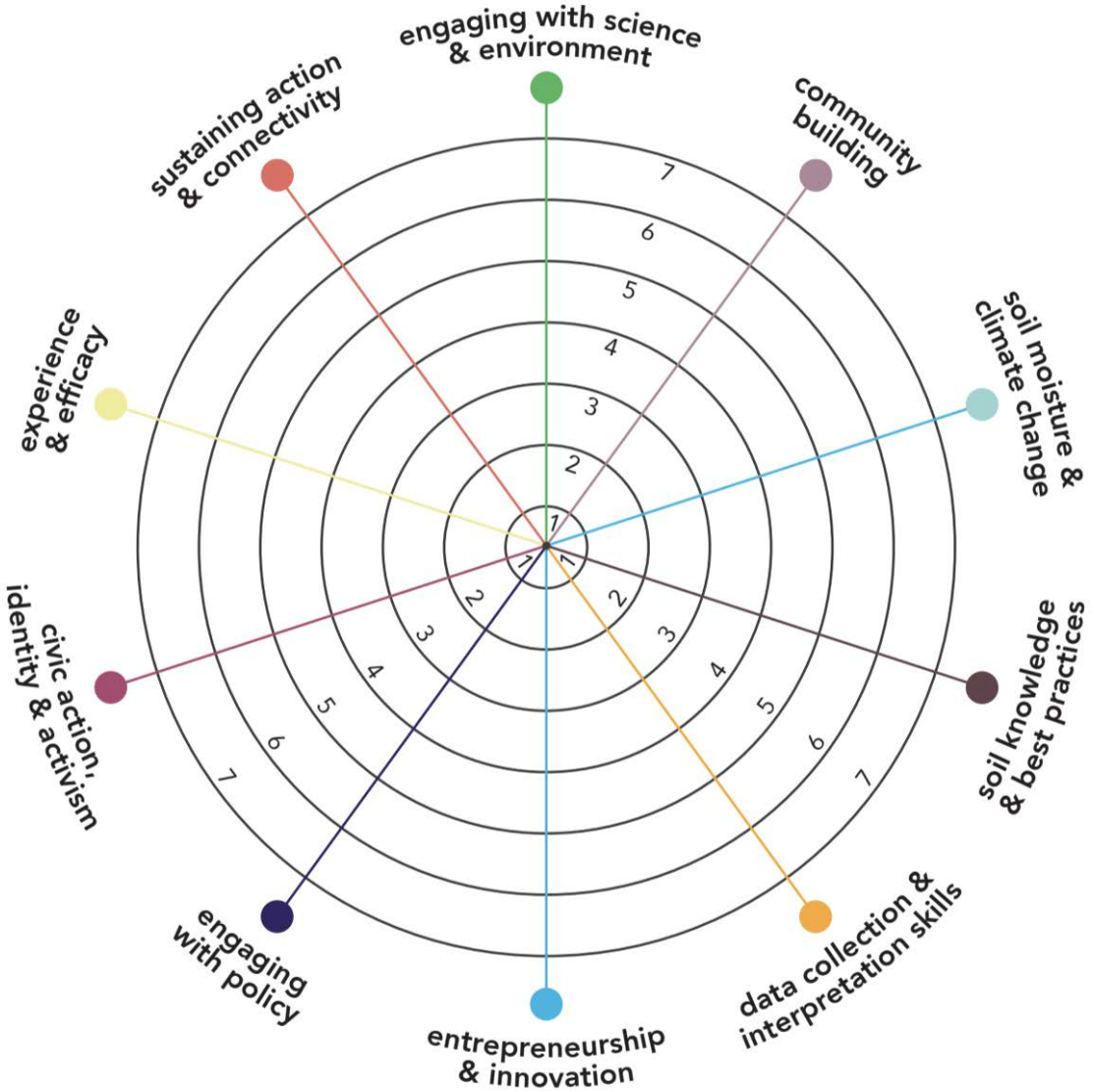


Figure 2.8 Evaluation Canvas Diagram with the indicators of impact

Although the Community Champions completed the canvas from their own perspective, Figure 9 is organised into GROW Place names in order to present information in a simple manner. Because the participants completed the canvas as a result of pair discussions, their rating may appear similar which could bias the results. For example, Portugal 1 and Portugal 2 paired together, while Portugal 3 was paired with another Community Champion, the similarity between Portugal 1 and Portugal 2 can be noticed.

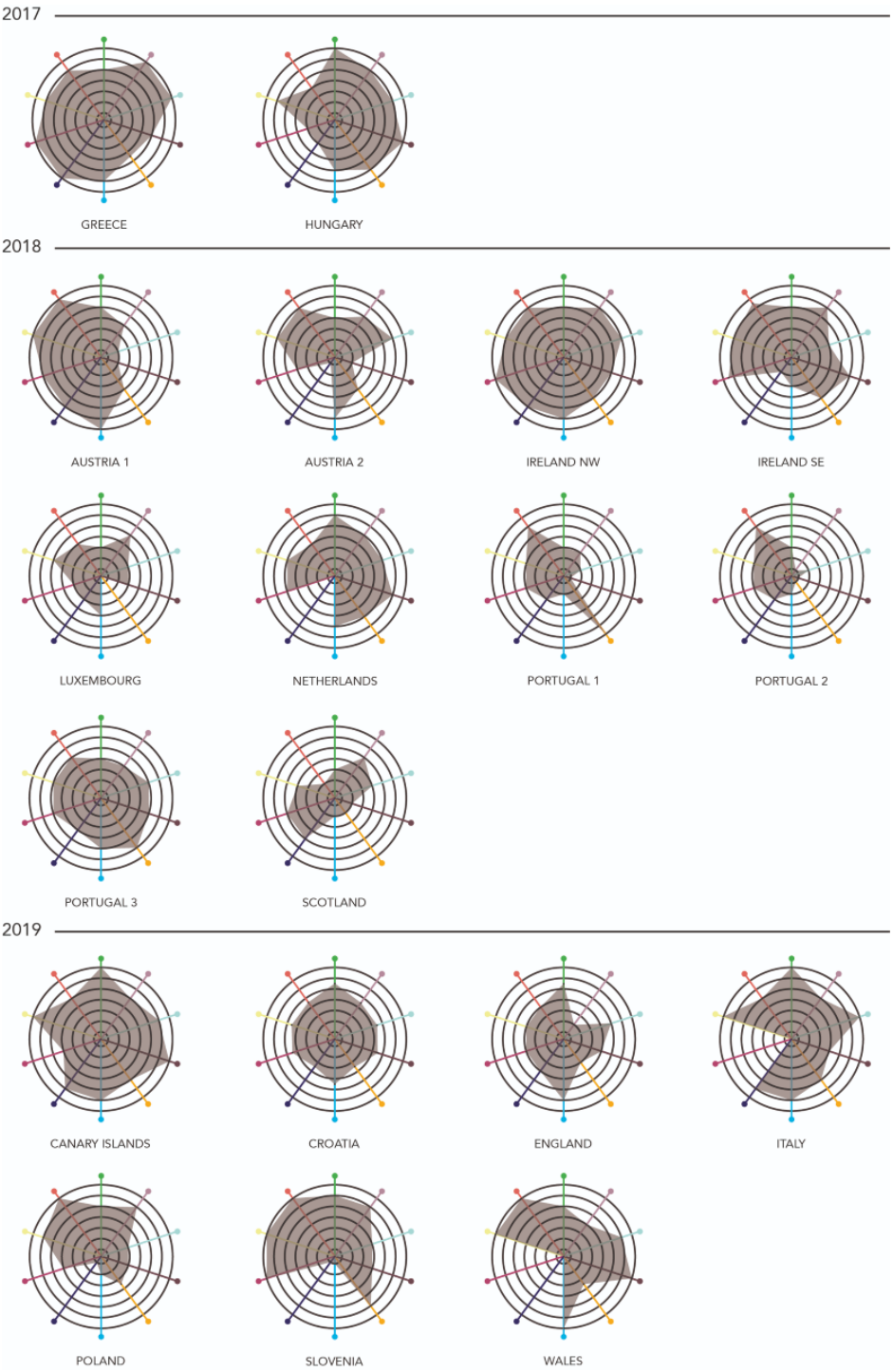


Figure 2.9 Overview of Evaluation Canvas by country and set-up year

Table 2.3 summarises the data and shows the impact through various indicators. It provides average, minimum, maximum scores along with the count and percentage of low and high impact on these indicators. Note that 0 and 1 are defined as low impact and 6 and 7 are defined as high impact. If we look at the average impact, the highest impact is observed on experience and efficacy and the lowest impact is observed in engaging with policy indicator. Engaging with policy is an indicator several Community Champions rated low although several forestry departments engaged in the mission in many GROW Places and new connections were made. This might be due to the fact that many participants feel removed from policy making circles and do not consider their activities to be of policy significance despite liaising with governmental organisations. It could also be due to the short time span in the project. James from Croatia Central commented:

> *"Sadly, the project ends on October 31st. This means that there is not enough data for the forestry commission, but at least I made contact and was given access to their land". James, Central Croatia*

Rank	Indicator	Average score	Min score	Max score	Count of low impact	% of low impact	Count of high impact	% of high impact
1	**Experience & Efficacy**	5.4	3.5	7	0	0%	9	50%
2	**Sustaining Action & Connectivity**	5.1	2	7	0	0%	8	44%
3	**Soil Moisture & Climate Change**	4.8	3	7	0	0%	4	22%
4	**Engaging with Science and Environment**	4.8	2	7	0	0%	8	44%
5	**Entrepreneurship & Innovation**	4.7	2	7	0	0%	7	39%
6	**Community Building**	4.4	0	7	1	6%	4	22%
7	**Soil Knowledge**	4.2	0	7	2	11%	4	22%

	& Best Practices							
8	**Civic Action, Identity, & Activism**	4.0	0	7	2	11%	4	22%
9	**Data Collection & Interpretation Skills**	4.0	0	7	2	11%	5	28%
10	**Engaging with Policy**	3.7	0	7	3	17%	5	28%

Table 2.3 Evaluation Canvas Impact Summary

The Community Champions were recruited through two different calls for applications: one in April 2018 and a second in May 2019 to set up GROW Places. (The recruitment process is reported in detail in Deliverable 2.4 - *Community Champions Programme*). In addition, the Climate Change Mission also builds on the Pilot Mission which was undertaken in there Grow Places, Alexandroupolis (Greece), Cloughjordan (Ireland), Miskolc (Hungary) between November and December 2017. The impact of the mission was expected to be different in the former and latter GROW Places. The Figures 2.5.2 (above) and 2.5.3 (below) demonstrate the length of the mission on the GROW Places.

In most of the recent GROW Places, several Champions wrote that due to the short time span, the impact is not high yet. *"We can see how the project has connected our community as we now interact with many sensor users on multiple levels. However, it does not have the highest rate since we joined the project very late and the impact of the networking is not so great (yet)."* mentioned by Ana from Slovenia. She rated 1 both entrepreneurship and innovation and engaging with policy indicators while she rated the other indicators high. Ana noted "*We have not been involved in the project long enough to show such impacts.*" On the other hand, in Alexandroupolis (Greece) and Ireland we can observe the greatest impact (see Figure 2.10) and they have been deploying sensor the longest period of time including their involvement in the Pilot Mission. The long deployment period allowed them to build on their community and develop impact.

Conversely, in El Hierro (Canary Islands), the impact is substantial even though it is a recent GROW Place. In El Hierro, they involved the local authorities early on, and the Community Champions highlighted that the local government has been actively involved in the project which led to higher impact. In addition, as the resulting GROW data are meaningful to their growing practices, they were able to

interpret the data and take action (They saved water by 30%). This is further discussed in Understanding the soil and taking action section. If we look at the results of Qlik Sense analysis on associations of GROW Place Set-up with categories of impact (Figure 2.11), unexpectedly, we observe that the average impact appears to be similar on various dimensions, even greater amongst new GROW Place Champions. Yet, 'community building', 'civic action identity and activism' will be the exceptions.

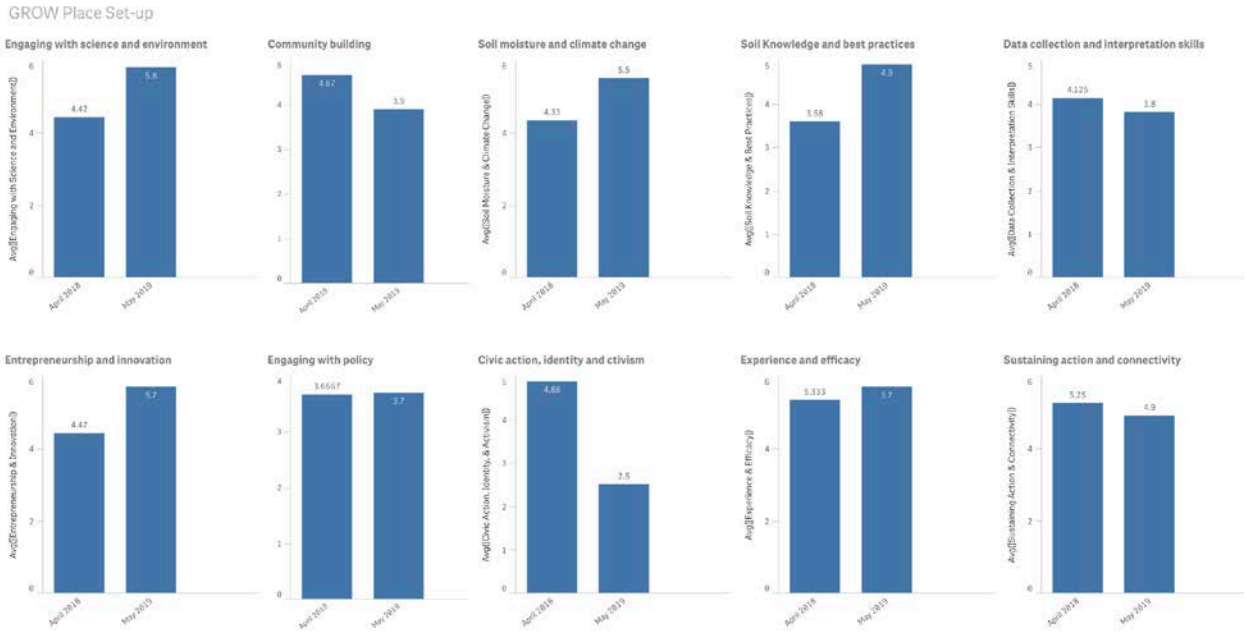


Figure 2.10 Results of Qlik Sense analysis on association of GROW Place Set-up with categories of impact

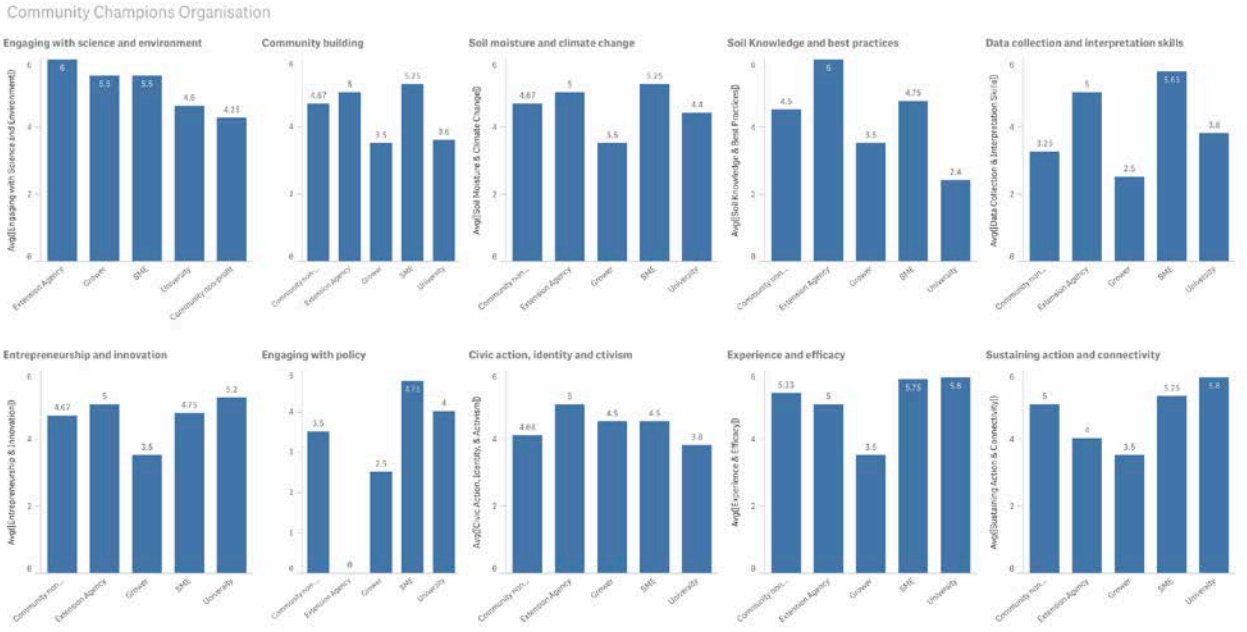


Figure 2.11 Results of Qlik Sense analysis on association of type of organisation with categories of impact

Understanding the soil and taking action

The mission was not built around entirely good will and stewardship, collecting data has direct practical implications on participants' growing practices. Upon completing the initial prescriptive setup, sensor holders in many GROW places are motivated to spend additional hours on collecting their soil data as they are interested in the resulting data to improve their soil practices. Undoubtedly, in areas such as Italy, the Canaries and Greece, where farmers need to irrigate regularly their crops, the importance and impact of sensor data to improve growing practices are rather visible. For example, in the Canary Islands, just one month after the start up, some farmers realised that they were over irrigating their banana crops, and as a result they have reduced the use of water for irrigation by about 30%.

> *"On our farm, we reduce a water use by 30 % just after month of data collection. We found that the plants are happy enough with 40 min irrigation instead of 1 h."*

Similarly, the growers from the Netherlands GROW Place have collected evidence and gained confidence in methods they follow. "*Micro water management (in the ditches, with cover crops) works! Grow sensors show this"*, Peter, Netherlands

The sensor data has produced other results unexpected to the sensor holders as well. Wendy, from Dundee, Scotland mentions:

> *"On a personal level (with 215 sensors) I was surprised how often the ground was recorded as being dry. This is not what I expected and has led me to make sure that there is more attention given to soil improvement and watering in my own growing area" -Wendy, Scotland*

Karine and Tania from Luxembourg GROW Place also noted that sensor data help them and the sensor holders to understand their soil better. They found out that soil moisture has a high spatial variation, with the same field we got different values for different sensors. Soil moisture was very different on different soils land use/exposition during the dry spell in summer.

> *"One of our participants made a post on Facebook with values from sandy and loamy soils during the very dry spell in June and realised that there was a difference of a bit over 20% between his site (clay soil under a light forest) and a south facing field with sandy soil (7%) from another participant who posted a comment".* Karine

and Tania, Luxembourg

Data Innovations

The climate change mission triggered several opportunities for open science and innovation catalysed by participatory methodologies, increased networks and knowledge exchange activities within and amongst the members of the GROW Places. Several Community Champions and superusers have accessed and used their data in novel and highly contextual ways, the emergence of local data use is a key indicator for social innovation. For example, in Italy, the data will be used for hydrologic modelling by Politecnico Di Milano. In Slovenia, the community champion aims to include the data in the thesis of her master of research.

In Austria, Anna Wawra (AGES) who has conducted long term field experiments on tillage treatments in relation to chemical, physical and microbial soil parameters as well as the amount of yields and quality of crops since 1988, designed a GROW experiment on the effects of different tillage methods on soil moisture, demonstrated that minimal tillage keeps more soil moisture and is the highest in organic carbon. This research would impact greatly places facing desertification. In addition, they have designed an experiment for the tea bag index with school students (http://www.teatime4science.org/about/the-project/). This simple method allows to understand soil moisture using teabags. Currently, they placed sensors next to the tea bags, the GROW moisture measurements complemented the tea bag index experiment. This research would test different soil management practices and raise awareness.

In Greece, Giorgos Galetsas, a forester working with the National Park, uses the sensor data to understand the behaviour of migratory birds in relation to soil moisture and to inform policy making. He combines soil moisture data with other GIS data to monitor flooding in a Natura 2000 wetland (Evros Delta) which attracts protected migratory birds (anser erythropus). Agroknow is a Greek company who won the GROW Data Pitch and is now using GROW data to demonstrate new services for Greek wine producers.

The Ethnological Museum of Thrace and Place Identity NGO co-hosted GROW's #GROWSoilHealth events in Alexandroupoli and got interested in the issues covered by GROW. This gave birth to a local, spin-off project called KOINO EDAFOS ("Common Ground") which eventually received funding (50.000 euros) from the Greek Green Fund in order to design and implement citizens' workshops, educational programmes and awareness campaigns on soil protection & regeneration in the region of Evros. The project uses participatory methodologies to deliver additional insights for policy change at local, regional and national level and creates an open educational toolkit on soil for schools to replicate.

An early career researcher has used GROW sensors as part of her research within the FLASHFLOOD project, aiming to set up a pilot hydro-meteorological monitoring system adapted to local and sudden events such as summer storms and flash floods. The participation in the GROW project is an opportunity for FLASHFLOOD researchers to multiply the humidity measurement points on the different soil types, micro-topography and geologies that characterize the Ernz Blanche basin.

Engagement with Policy

GROW has also demonstrated citizen science is a powerful approach to inform an increasingly complex environmental policy landscape and to meet the growing demands from society for more participatory decision-making. All the policy activities, training and insights achieved during the project are reported in Deliverable 3.5 *Engagement activities and their impacts on policy development*. Grow Observatory supported “bottom up” actions in GROW Place communities in which participants are increasingly involved to be an active part in policies. This has contributed to a vibrant and productive citizen science-policy interface. Most of the data innovations mentioned above also inform policy making.

In Greece, the GROW Policy Workshop (03-04.09.2019) was attended by Mr. Petros Kokkalis, Greek Member of the European Parliament who has been following the news on GROW activities for several months. Kokkalis is a dynamic advocate for the Sustainable Development Goals at EU and UN level and regularly uses GROW as an example demonstrating the potential of Citizens' Observatories. Similarly, the GROW Public Event "Citizens & Open Data for Sustainable Development" (07.02.2019, Athens) was attended by Members of Parliament and officers of the Greek Ministry of Environment, who expressed interest in the Citizens' Observatory model for environmental management and massive citizens' awareness. GROW Place Greece offered new spaces and opportunities for young growers and scientists in the remote city of Alexandroupoli to meet, discuss local burning issues, needs and concerns and take collective action. On the occasion of the 2019 municipal elections, members of GROW Place Greece led the creation of a new independent political group to advocate for the Sustainable Development Goals at local level. The group, named FAROS ("Lighthouse") ran for the Community Council and received 26,1% of the votes, following a successful campaign that raised awareness about local environmental challenges including soil pollution, deforestation and climate change. FAROS elected 4 out of 15 members at the Community Council, including GROW Community Manager Pavlos Georgiadis, and GROW Community Champion Kiki Chatzisavva. The events we organised for World Soil Day 2019 as part of the #GROWSoilHealth campaign brought together key local stakeholders, including the Mayor of Alexandroupoli, who attended scientific talks and was exposed to worrying data about the usage of dangerous chemicals (herbicides and pesticides) in public spaces by his administration. Extensive coverage of this issue by the local press put pressure on the Municipality of Alexandroupoli to reconsider agrochemical procurement processes and take action for soil protection.

In El Hierro, the Local Government (Cabildo) Department of Agriculture is an active player in the GROW community. They are the biggest sensors user deploying 123 sensors installed by the Community Champion on their government land, and cover nearly all climate zones in the island.

In Luxembourg, the forestry and nature administration has taken and distributed a batch of over 300 sensors to foresters over the whole country. They aim to have a good coverage of soil data humidity and temperature in forests, and to obtain a good dataset to from GROW sensors which they could integrate into an ongoing study with other forest parameters. Similarly, the Croatian Forestry Department has joined with a small sample area, as a staff member introduced some colleagues to the project. The Community Champions of Luxembourg also invited the soil administration to their event organised on World Soil Day. Several GROW Places aimed to influence policy and promote soil friendly policies but policy making is long term endeavor. In Croatia, James has worked in collaboration with the forestry commission.

> *"I have made a connection with the Forestry Department. This has never been done before. My contact was delighted to be exposed to citizen observatory, soil sensor technology, data collection/interpretation […] Too early to evaluate this, however there is huge potential. Policy Making is often a long-term impact but informing policy makers so that right decisions will be made". James Wardel from Central Croatia.*

Gil from Portugal highlights how community involvement driven by the mission has societal impact and hence informing policy makers.

> *"GROW allowed the organization of several scientific and celebration events open for the public which brought interest into soil monitoring and soil practices. We also managed to bring the soil as a commons to the European parliament during the GROW project."*

2.5.2 Technical challenges and opportunities

Using low cost sensors made it possible to gather data from thousands of points and formed the largest citizen-managed on-the-ground soil moisture sensor network but presented some challenges. It was noted that setting up the sensors is time consuming and technique sensitive. Besides, growing is labour intensive activity almost all Community Champions mentioned the challenges of initial set up. Tanja from Croatia also points out the importance of timing,

> *"The timing for the installation of the sensors proved the biggest challenge. July and August are the peak tourism and event season, and there was a significant heatwave during this period."* Tanja, Dalmatia, Croatia

Some of the difficulties mentioned include finding geographically suitable areas, maintaining sensors, updating firmware and uploading data. In addition,

technical errors as a result of battery problems, extreme conditions such as heavy snow and rain and animals eating sensors lead some sensor holders to lose their determination in the mission and drop out (Scotland, Ireland, Croatia 2). To overcome these difficulties, the GROW team and the Community Champions provided activities and support to sustain participation to ensure that sensors are maintained and users continue gathering data over the long term. For example, in the Canaries, the community champion has installed all sensors to be used by the sensor holders. Certainly, the sensors produce a large amount of data, the GROW team supported the sensor holders in the process of making sense of data through MOOCs, instructive manuals and online and one-to-one support. A method for the participants to support each other could be designed and applied to overcome some of the aforementioned difficulties.

The Flower Parrot Sensor was initially designed and manufactured to be used indoors. GROW has extended the use of this low-cost sensor to outdoors. This lead to increased failure rate. Some of the sensors users even extended the use of sensors for their experiments. The Portuguese Community Champion worked closely with Walt, a superuser, to design permaculture experiments. Although these experiments are important for data innovations, they moved outside of the usage protocol recommended by the GROW Observatory leading to higher failure rate and dissatisfaction.

> *"Moreover: the most extreme rate of failure has been w/r/t those sensors deployed in my test groups (where, by design, sensors are exposed to more standing water), such that -given the very small sample base deployed in each test- the tests are essentially all invalidated". Walt, Portugal*

In addition, the ecological impact of the sensors were concerning for some sensor holders. This includes the sensors' plastic packaging and the use of alkaline batteries (mentioned by Ireland and Scotland).

Several GROW Places made suggestions for alternative sensors to collect data. Wendy from Angus, Scotland points out:

> *"From my conversations with growers and farmers I think there may be interest in better quality sensors which measured pH and organic content.". Wendy, Angus, Scotland*

A lack of time, requirements and priorities of laborious growing are amongst challenges mentioned by the Community Champions.

> *"GROW is about linking the pins with personal enthusiasm. In the Dutch highly competitive environment this is hard to organise. Nevertheless, the project produces valuable connections between farmers, policy makers and advisors; and interesting insights"* Peter, Netherlands

Certainly, these challenges more pronounced when a high number of sensors are deployed by a single person. Walt from Portugal who placed 220 sensors commented on this,

> *"It's a full half-day job every two weeks to collect & cloud-sync the data". This could be addressed for the future projects".*

2.6 Next steps for GROW Place Communities

The challenge with short term citizen science projects is that funded activities end, but communities remain. GROW has created and inspired a network of connected communities across Europe with a motivation to continue sensing their environments to create positive change. Online meet up on 3rd Oct 2019, 8 out of 10 Champions reported being motivated to continue collating data after 31st October. Several growers want to carry on utilising the sensors. Jonas from Hungary points out,

> *"growers also ask frequently that (if) they should give back sensors after the end of the project, because they would like to use these long term".*

At the request of participating communities, GROW has facilitated a number of channels and resources to support the long-term sustainability of GROW Places and citizen sensing and collaboration. As part of the Community Champions Programme, a Community of Practice (detailed in Deliverable 2.4) was developed to strengthen connections amongst Community Champions beyond the funded life of the project.

Final face to face events in several GROW Places took place throughout October 2019 around the European Week of Regions (7- 10th of October). These meetings were designed with a view to foster the self-sustained long-term activity of GROW Places communities. The meeting objectives were:

- Celebrate citizens' participation in the GROW's Changing Climate Mission and their contribution to the GROW Observatory
- Share GROW Place case studies with local participants and other stakeholders
- Disseminate project findings and the release of the citizen-generated dataset with its DOI, including also insights from the OPI and IW events that will take place in September.
- Provide details of the alternative mobile app to replace Parrot's Flower Power app and share it on GitHub to enable the tech community to maintain it and develop it. This development will enable sensor users to continue using their sensors after 31st October.
- Share Opportunities for GROW Places post 31st Oct 2019 with the community:

- Offer an opportunity for participants to reflect on and provide feedback on their participation in the project using the GROW place evaluation tool

	Evaluation Canvas

	Evaluation Canvas Facilitation Protocol

3. Living Soils Mission

The Living Soils Mission aimed to develop and support an active network of small-scale growers and gardeners who grow food by using, and collaboratively investigating, practices that regenerate soils and create resilient ecosystems. The objectives were to:

1. Help growers to access information and advice tailored to their location and growing conditions.
2. Increase the number of people growing in ways that regenerate soils and support diverse and resilient ecosystems.
3. Investigate regenerative practice(s) at the smaller (i.e. not routinely mechanised) scale of growing and disseminate findings.

Evidence-based and sustainable practices
GROW citizen science has contributed to the development of effective land management protocols (e.g. smart water resources or nutrients management associated with agricultural land uses) in WP3 and WP1 through provision of quality controlled and validated crowdsourced data to environmental monitoring systems in WP5 and WP4. Such user-led information facilitates the provision of tailored, area specific, decision support information and growing advice (WP3).

Key land management techniques can lead to an improved land and soil quality or have positive impacts on the soil management of other environmental resources such as water, nutrients, or biodiversity. The Missions has raised awareness of how the relationships in the land system (i.e. between crop, soil, climate, crop management and environment) are, in most cases, complex and hard to capture without scientific methodology.

The Mission was open to participants from around the world, although the focal region for activity was Europe. We have used the term “regenerative” to recognise the need for action to improve soils and ecosystems over existing conditions, and to indicate approaches that balance production of food with regeneration of soils and enhancement of ecosystems.

As part of the Missions, training through the MOOCs as well as a wide range of resources freely available on the GROW Knowledge Base, has provided free actionable resources to enable citizens to formulate scientific questions and design experiments to test the effectiveness of different land management activities and as a result, to empower them with the right data to secure a more active role in land governance and local land policy negotiations (WP1).

3.1 Results from Regenerative Practices survey

As part of the Citizen Science: From Soil to Sky MOOC in 2018, growers were asked to take part in an online survey into which regenerative growing practices they

use and whether they thought they worked or not. The survey revealed that growers were most interested in the practices of polycultures and companion planting and yet many felt that they weren't sure on whether or not they really worked (Figure 3.1). This formed the rationale for the Great GROW Experiment.

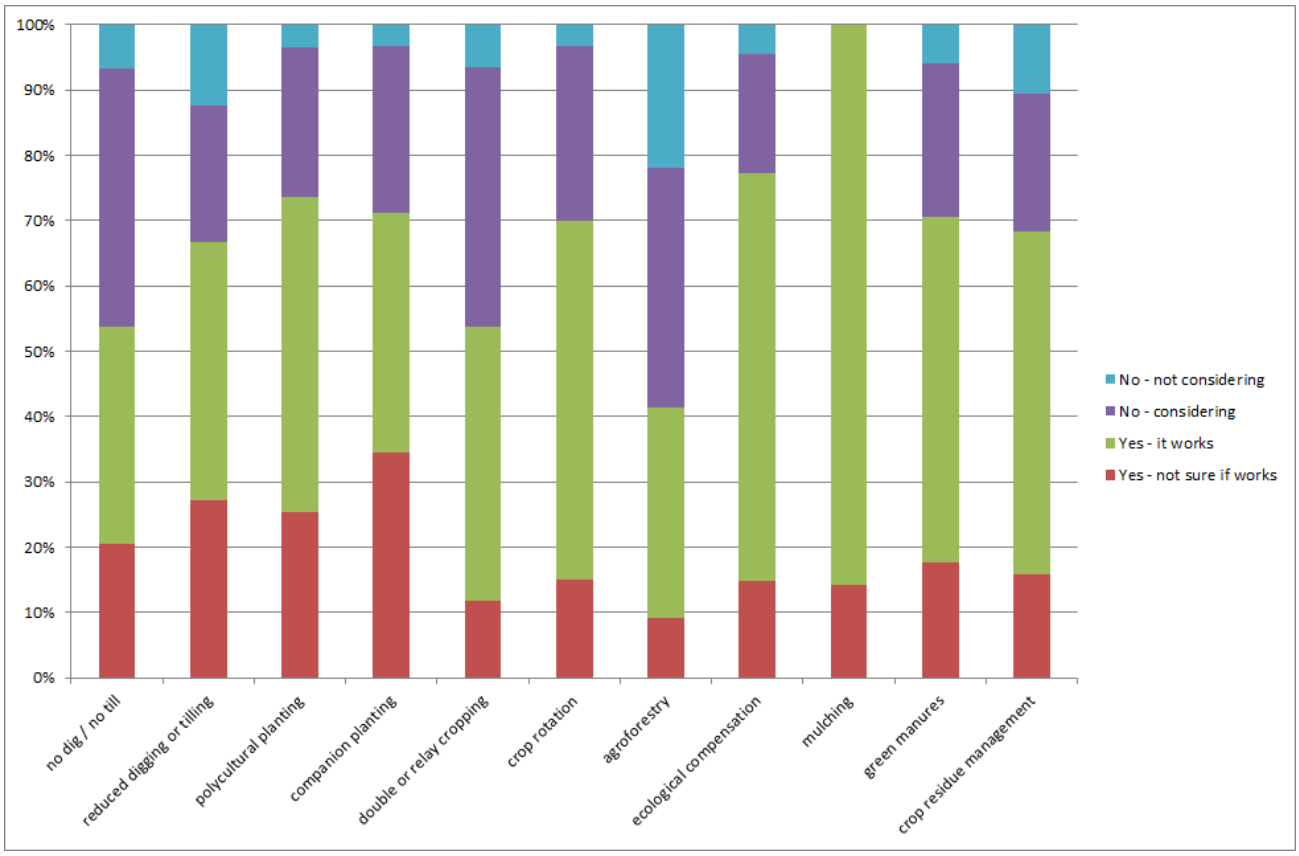


Figure 3.1 results of the 2018 regenerative growing practices survey with percentage of respondents who were practicing techniques and whether they thought it worked or not.

Technical issues with the repeat of the survey in 2019 means that there is not quantitative data for if responders have taken up other practices or become more confident in whether the techniques work since 2018. However, the Experiment final evaluation survey results suggested that many people will take up polycultures as a new practice and continue experimenting with them:

"I often grow polycultures but not always sure how well they work, so it's interesting to see lots of people doing the same thing. It feels nice to have connected with a like-minded community." (Final evaluation comment).

"Not planning any formal experiments, but do plan to mix up my four-crop rotation a bit more & spread legumes across all four plots. Also plan to try mixing garlic with brassicas more." (Final evaluation comment).

3.2 The GROW Experiment

The Great GROW Experiment ran in 2018 and was a citizen research comparison of the productivity of three crops grown together in polyculture and separately in monoculture. The crops were climbing beans, spinach and radish. Thirty-two experiment participants ("experimenters") from nine European countries completed the experiment and submitted data. Results showed that overall polycultures were significantly more productive. This was also true for over 70% of individual participants. There were no distinct patterns in overall yields with relation to geographic location (latitude or longitude), but some trends in timing of harvests are apparent. Below we present a rationale for the experiment, the key research questions, how we did it (method) and what we found (results).

3.2.1 Rationale

Polycultures – growing several crops together at the same time – have been shown to have benefits in terms of crop yield, resilience to pests and disease, and enhancing wider biodiversity. Whilst crop combinations are of high interest to permaculture growers, mixes of three or more crops have not been extensively studied scientifically and much remains unknown. In 2018 we brought together growers and scientists to investigate these practices through citizen science in GROW (more details about the rationale and initial plans can be found in the blog post https://medium.com/grow-observatory-blog/polycultures-v-monocultures-the-great-grow-experiment-2018-5fac8a6a3879t).

3.2.2 Research questions

1. Is there a difference in yield (grams per square metre) of beans, spinach and radish when grown as a polyculture compared to when grown as monocultures? Is there a difference in the total yield of these three crops? Is there a difference in the yields of each individual crop?
2. Is there any variation across bioclimatic zones (for example, across Europe or the world) in the yield of each crop?

We also intended to investigate impact on soil pH and nutrients: nitrogen (N), phosphorous (P) and potassium (K). Unfortunately, the low-cost test kits used proved highly unreliable when compared to laboratory tests. We were therefore unable to draw any conclusions from those results and they are not discussed further here. Alice Ambler of JHI is writing an article to share these findings.

3.2.3 Method

3.2.3.1 Study sites

Gardens, allotments, farms and other growing spaces around Europe were invited to take part. The ideal growing site was in a sunny area. Experimenters were advised that the site

should have no more than 25% shade, for example, less than a quarter of the site shaded, or the whole site shaded for less than a quarter of the daylight hours.

Figure 3.2. Experiment plot. Copyright: Adela Nistora |

The soil should have been suitable for growing annual vegetables. It should not be waterlogged, foul-smelling or heavily compacted. The whole growing site (all four experiment plots) was prepared according to experimenters' normal practice. This might be no dig or dug over, mulched, or with green manure dug in. All weeds were removed before planting the experiment.

Participants were asked to treat all plots equally in terms of preparation, maintenance and harvesting. Where intervention such as replanting non-germinating seeds, weeding, watering, or pest control was required this should have been noted with respect to each plot.

3.2.3.2 Crops and plot layout

The three crops were:

- round climbing beans (*Phaseolus vulgaris* "Cobra")
- spinach (*Spinacia oleracea* "Matador")
- radish (*Raphanus sativus* "Cherry Belle")

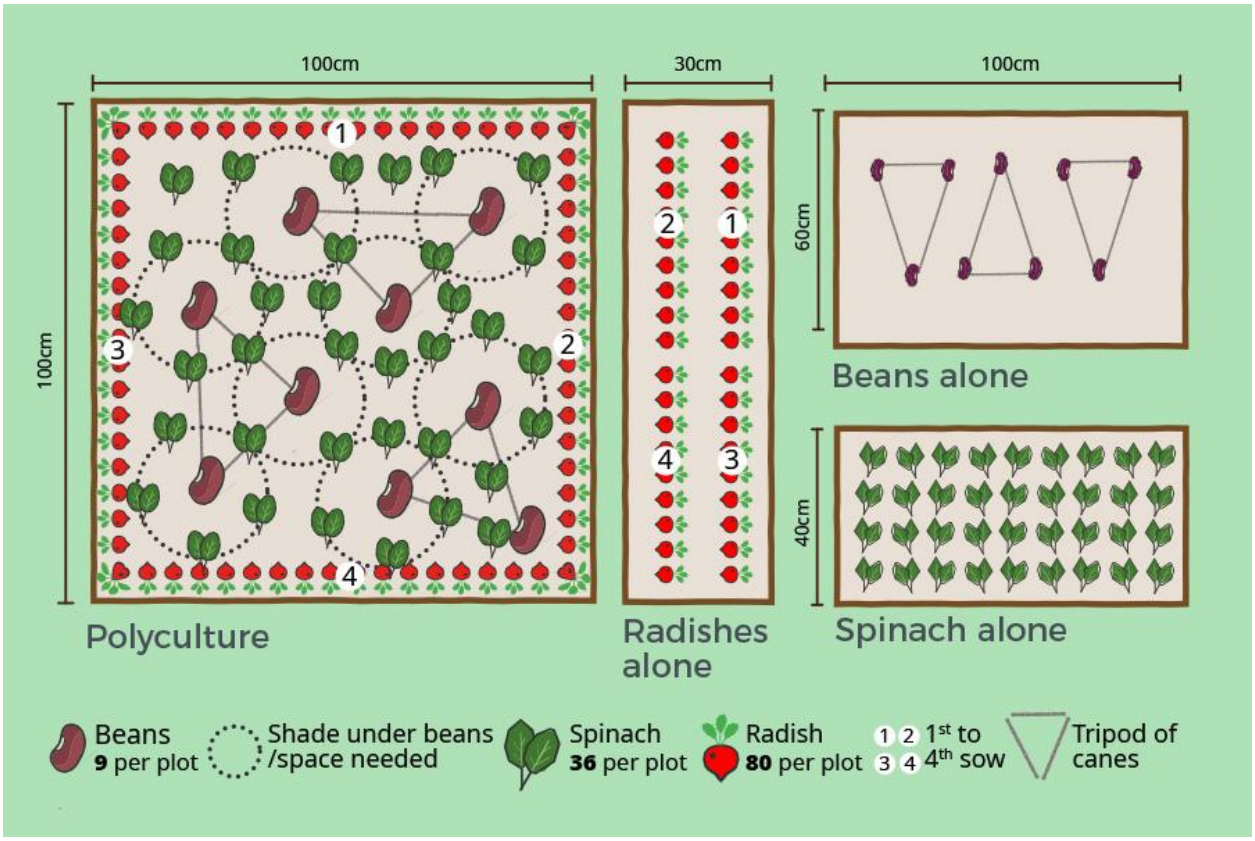


Figure 3.3 GROW Experiment layout

There were four experiment plots:

1. Polyculture: 1 x 1 metre. Nine beans, 36 spinach, 80 radish planted
2. Beans (monoculture): 1 metre x 60 cm. 9 beans
3. Spinach (monoculture): 1 metre x 40 cm. 36 spinach
4. Radish (monoculture): 1 metre x 30 cm. 80 radish

Each plot was separated from the others and any other adjacent growing plot by at least 50 cm. The plots with the taller plants (polyculture and beans) were located on the shady side (to the north in the northern hemisphere) of the others to minimise any shading influence on them. The seeds were planted with respect to the climate, and in the same way (sown indoors and planted out, or sown directly in the ground) and at the same time in both the polyculture and monoculture plots.

3.2.3.3 Measurements

Figure 3.4 GROW Experiment bean plants

Experimenters were asked to:

- Weigh and record each harvest of each crop
- Assess the quality of each crop on a scale from 0-5, with 0 meaning poor quality and five meaning very good quality.
- Note any interventions on, or observations from, the plots that could affect how well the plants grow.

We also observed other factors that can influence our results and can help us to understand differences between sites. These were:

- Slope angle and slope aspect
- Slope position
- Canopy cover
- Soil texture
- Stone content
- Site photographs

More details about the experiment design can be found on this blog post. https://medium.com/grow-observatory-blog/so-how-did-we-design-the-great-grow-experiment-962da8f9202

3.2.4 Results

From 68 participants who planted seeds, 34 submitted harvest results, and 32 had harvested more than one crop from both plots. The overall findings were that the polyculture was significantly more productive than the monoculture plot. For 71.9% of individual participants, the polyculture was more productive by area.

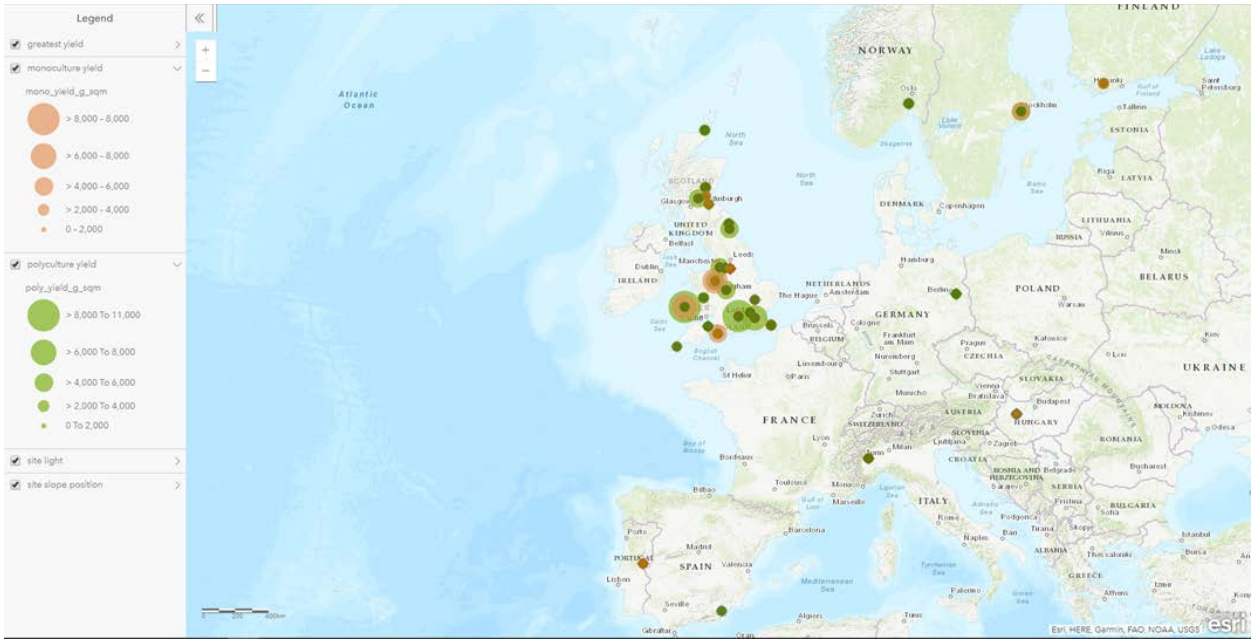


Figure 3.5 Map of experiment results. The size of the circle shows yield in grams per m^2 for the monoculture (orange) and polyculture (green) plots. An interactive version of this map is available at: https://www.permaculture.org.uk/research/great-grow-experiment

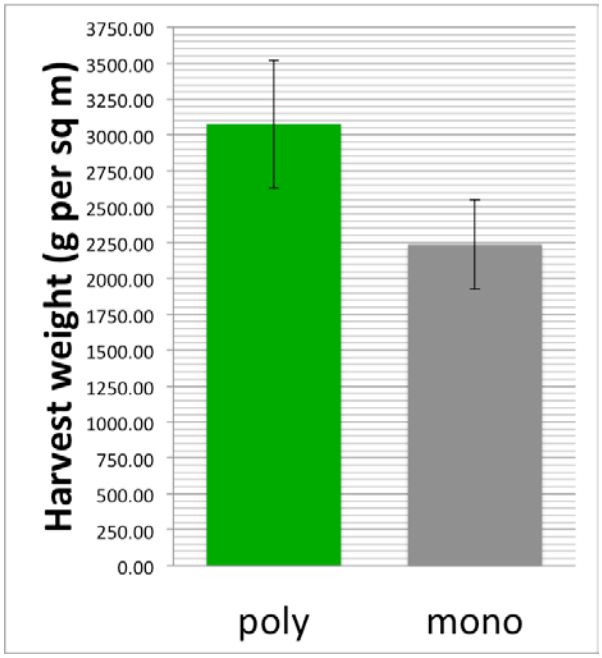


Figure 3.6 Experiment harvest weight results

Polyculture average of 3074.8 +/- 443.6 grams per square metre (3.07 kg per sq m)[1]

[1] These averages were tested using a Wilcoxon signed-rank test (non-parametric test for data paired by site to account for differences in location and management between sites) with resulting test statistic V = 403 n = 32 and p = 0.008.

Monoculture average of 2234.9 +/- 312.7 g per sqm (2.23 kg per sq m)

Looking at the results by crop, we found that this is largely from the beans (left) which were more productive in the polyculture plot. The spinach (centre) and radish (right) were slightly more productive in the monoculture plot, but these differences are not statistically significant.

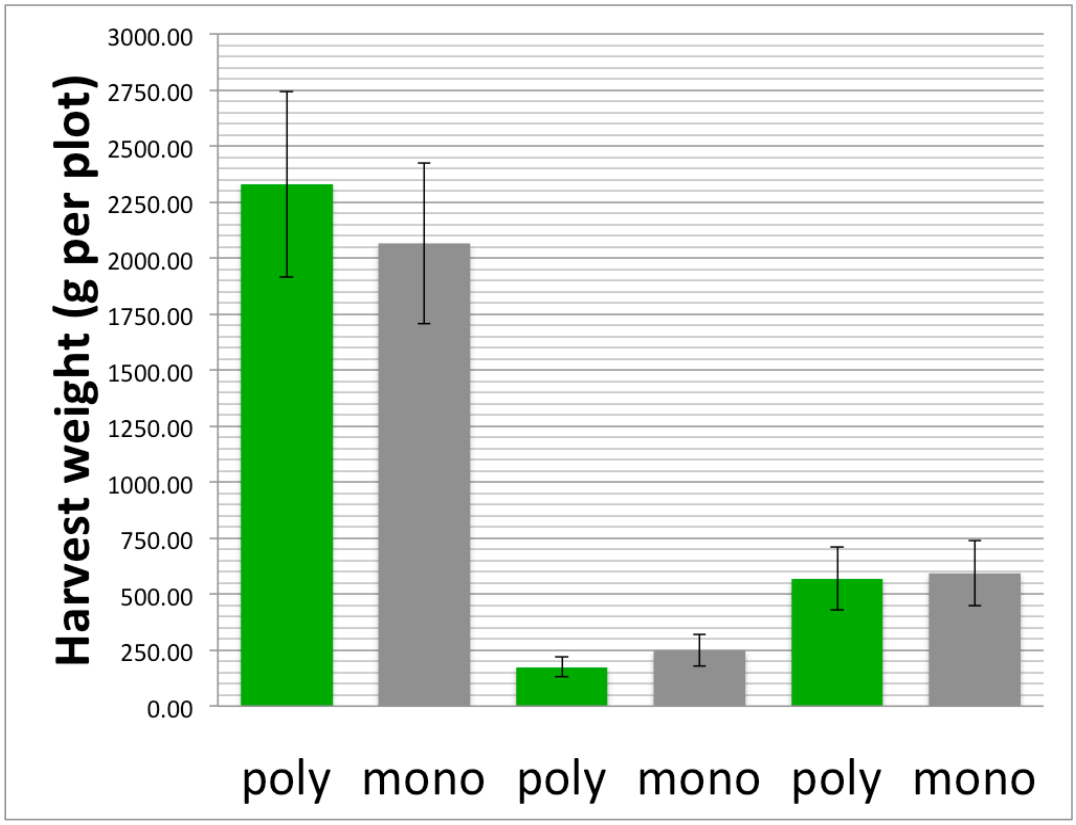


Figure 3.6 Experiment harvest weight results

The maps below show a comparison of total yields from the polyculture and monoculture plots across geographical areas. The size of circle represents weight of all crops in grams per square metre.

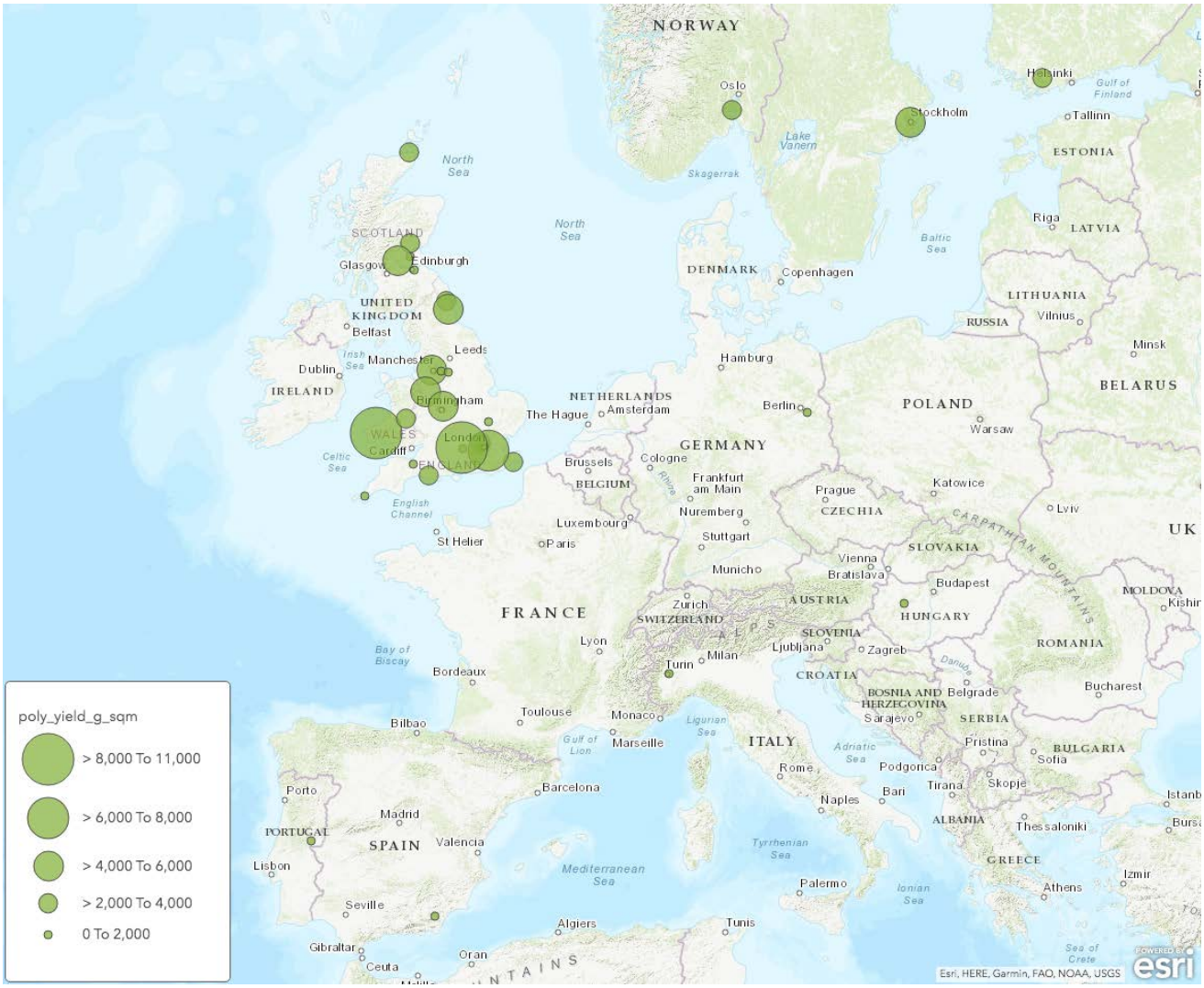


Figure 3.7 Map showing total yields from polycultures. Size of circle represents weight of all crops in grams per square metre.

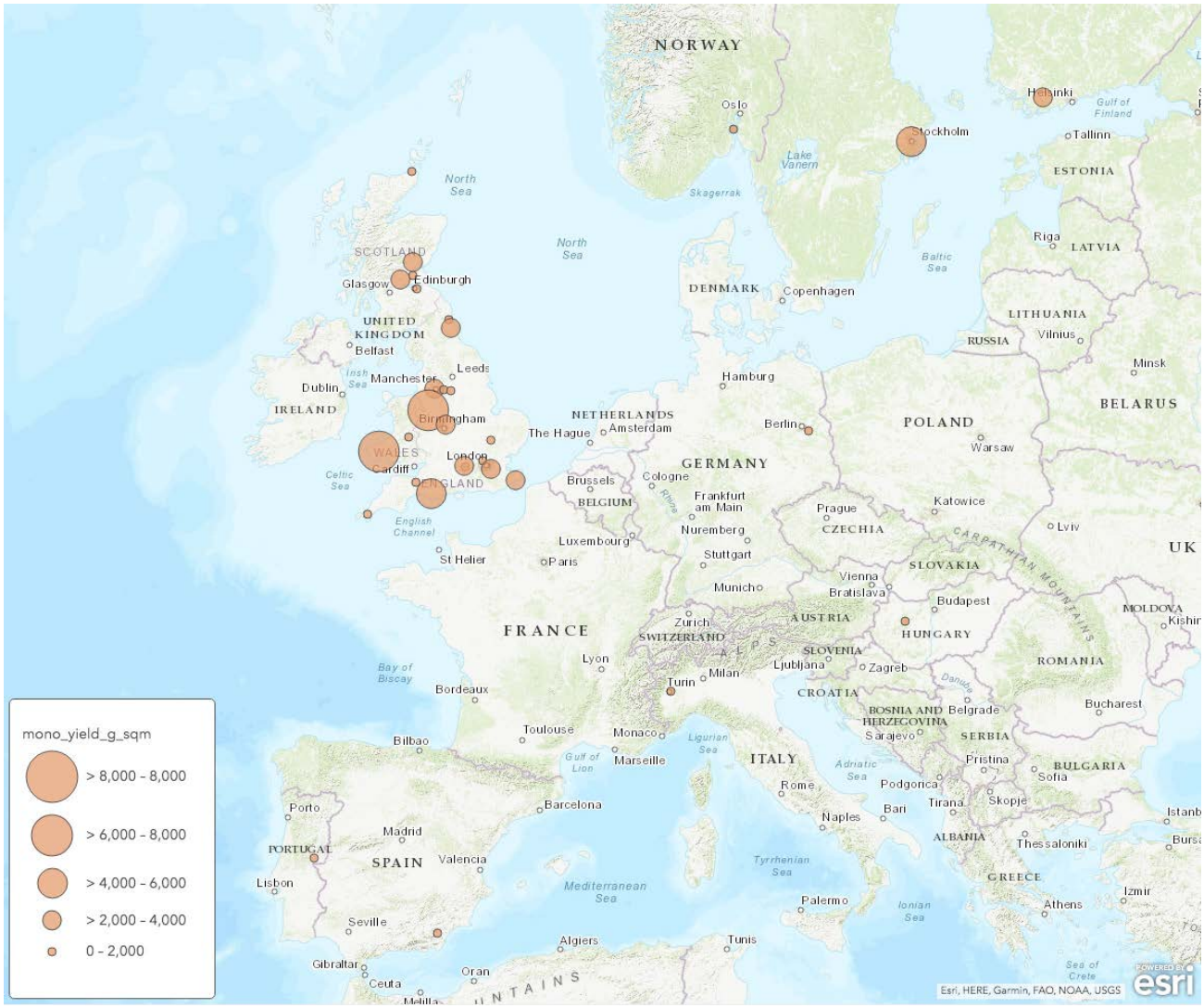


Figure 3.8 Map showing total yields from polycultures. Size of circle represents weight of all crops in grams per square metre.

3.2.5 Impact and Dissemination of the GROW Experiment

A survey and interviews were carried out to collect feedback from growers about their participation in the GROW experiment. A full research paper titled “The Great GROW Experiment: challenges and opportunities for hypothesis-based citizen research in food growing” presents all the findings and reflections from the experiment. This paper has been submitted for peer review to an academic journal and will be shared on the GROW repository once accepted for publication. We provide a summary of the findings below.

Evaluation of the experiment, beyond the quantitative results presented in the previous section, included collating comments from participants and an online survey. 161 growers signed up to the experiment, with 21% completing it, which is higher than the average 10% retention rate retention rate of mass participation citizen science projects (Lakeman-Fraser et al. 2016). In December 2018,

participants were invited to take part in an online survey created using the Bristol Online Surveys (BOS) platform to evaluate their experience.

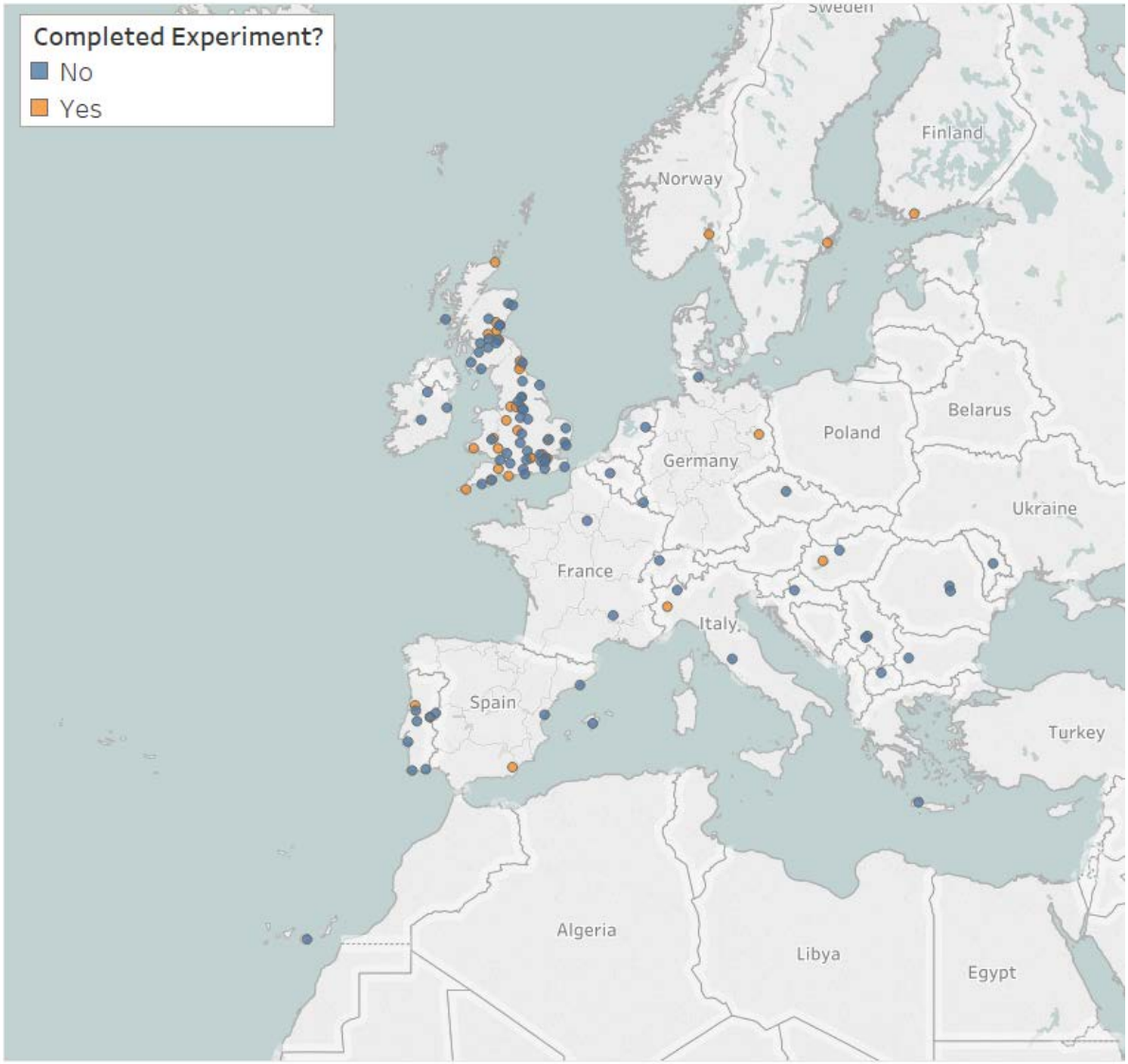


Figure 3.9. Map of experiments planted and whether they were completed or not. ©OpenStreetMap contributors.

The final evaluation survey revealed the most important reasons for taking part in the Great GROW Experiment were to contribute to scientific research and learn new skills (Figure 3.10). This agrees with findings from other citizen science projects, and volunteering in a wider sense (Clary and Snyder 1999; Curtis 2015; Rotman et al. 2012; West and Pateman 2016), with the altruistic motivation of 'contributing to scientific knowledge', and intrinsic motivation 'learning something new', being rated the most important reasons for taking part in citizen science activities.

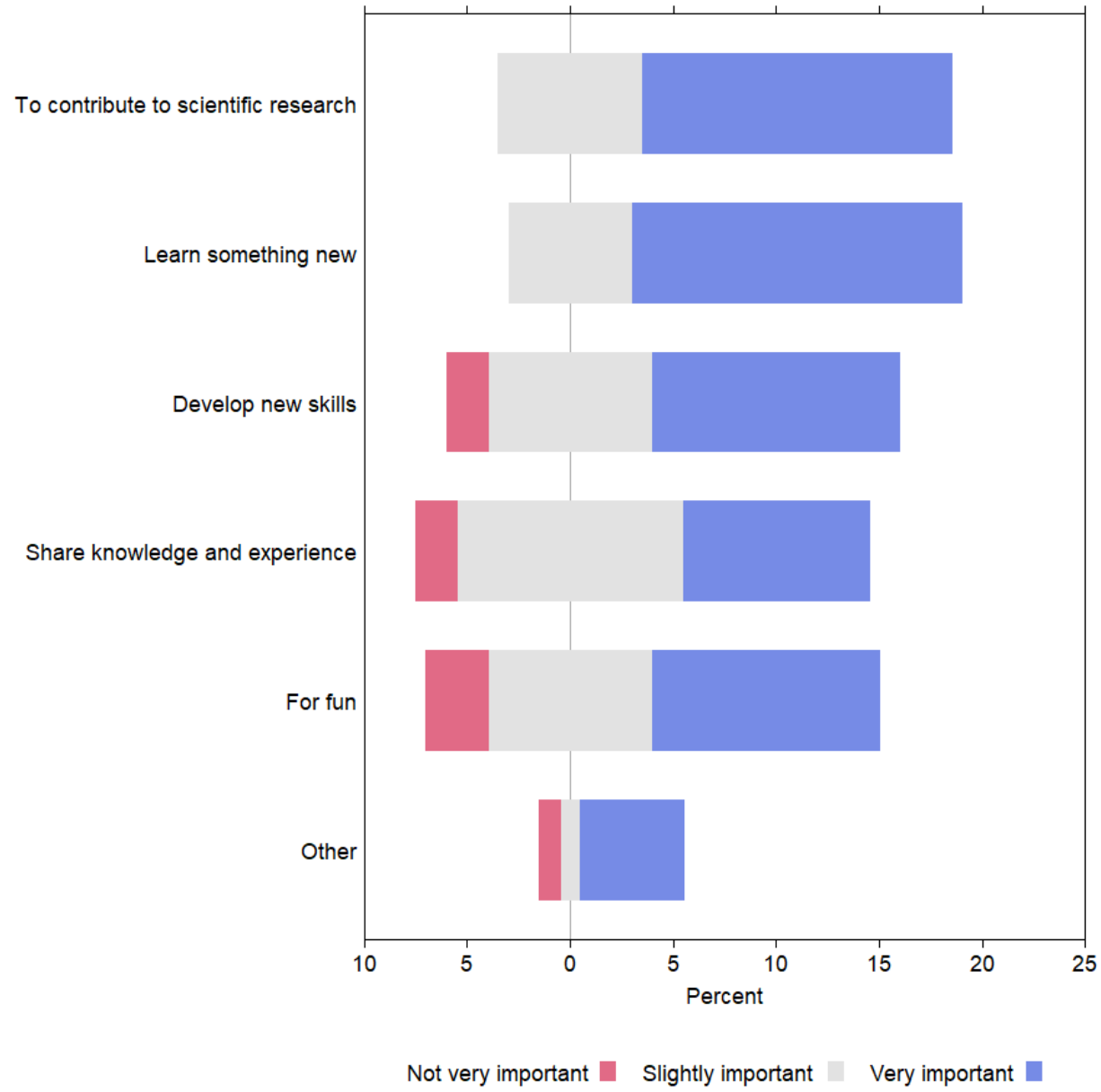


Figure 3.10 Diverging stacked bar chart for Likert responses from the final evaluation survey showing how participants rated the importance of different motivations for joining the experiment.

Sharing knowledge and connecting with others was also a common theme to the open text response:

"*to connect to other like-minded people and see how their experiments are going*" (final evaluation survey comment),

"*it feels nice to have connected with a like-minded community*" (final evaluation survey comment).

3.2.6 Challenges and barriers

Many of the challenges faced in the experiment echoed the usual challenges of growing food, including keeping the experiment watered, and protecting it from poor weather conditions (particularly the spinach) and/or pests. Although these challenges are always present in food growing, and other outdoor activities, drop-outs could have perhaps been reduced by providing clearer guidance for each possible scenario in advance. Not having enough time was the greatest challenge (Figure 3.11), which has been reported for other citizen science projects.

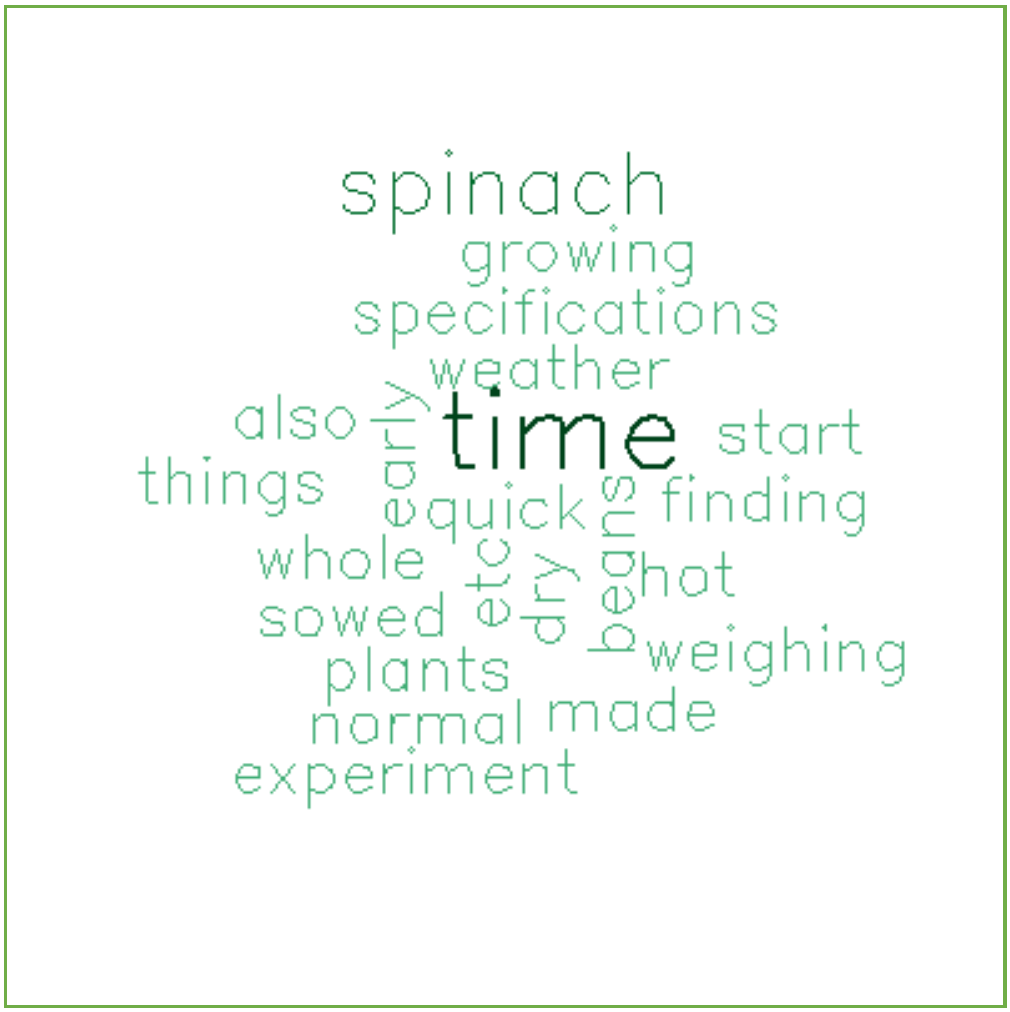


Figure 3.11 Word cloud summarising responses to "What did you find the most challenging part of the experiment?" in the final evaluation survey. The size of each word is proportional to the number of times it appeared in responses.

Experimenters appreciated the learning opportunity offered by running the online course alongside the experiment:

"[I enjoyed] *learning from the other GROWers and educators*"

(comment from final evaluation survey), the interaction with educators

"*the educators did a wonderful job taking us through this journey*" (comment from online course)

and with peers:

"*I enjoyed being part of a bigger project, and learning from other growers*" (from final evaluation survey).

However, the timing of the online course in April-May was problematic for planning a growing experiment:

"*the online learning was interesting but needed to be much earlier to allow me to do it in advance so I can finish it in time to plan, get stuff, do the research basics, sow etc.*" (final evaluation survey comment)

As other research has found (Lewandowski et al. 2017), participants reported a lack of confidence in their scientific skills:

"[the most challenging part was] *learning to be more organised with weighing and recording harvests*" (final evaluation survey comment)

"[the most challenging part was] *being systematic about harvesting and weighing. It made me think I'm not suited to scientific experiments.*" (Final evaluation survey comment).

Difficulties with the input of data through the GROW website may have impacted on participant experience and retention:

"[I had] *trouble inputting data (dates) on website*" (final evaluation survey comment), "*the online harvest submitting form isn't that great*" (comment from online course).

Despite these challenges 91% of final evaluation survey respondents said they would be interested in taking part in a similar experiment. Some participants (55%) were already conducting or planning their own experiments as a result of participating. A further 45% felt they would require some guidance and structure to be able to continue experimenting:

"*I would need the structure of your experiment to keep me on track*" (final evaluation survey comment).

"*I don't have skills and time to plan an own experiment but love to join to this* [sic] *activity with interesting research questions and nice community with excellent guiding*" (comment from online course).

Insights from the experiment indicate that hypothesis-based citizen science in domestic growing spaces can create new knowledge on small-scale food growing (Naomi et. al. in review.), improve scientific literacy and communicate scientific methodology to participants, increase citizen science retention rates through deep engagement (Burton et. al. in review), and, in the context of local food production, help growers, and growing communities, to make informed decisions about appropriate growing techniques. These quotes from participants reflect the value of this citizen research opportunities for small scale growers:

"Though I did not take part in the Citizen science experiment due to a smallish garden, I did do an experiment of my own, and during this course I have learnt to analyse my data and take conclusions that are not only going to help me in planning my next spring's crop growth, but has encouraged and inspired me immensely to the extent that I cannot wait to get started and I am making plans for my garden already, taking into account what I have learnt." (comment from online course).

"I would definitely participate in citizen experiments again if they are as well guided as this one. It has been a great learning experience, I also find it empowering and meaningful to do this not only for myself but for a wider community and for science." (Final evaluation survey comment)

A great story of a grower's participation in the experiment can be found in this blog post:

https://medium.com/grow-observatory-blog/meet-ionat-gardener-on-a-growers-journey-846198d568f0

The GROW Experiment concluded in 2018. However, in 2019 two GROW Partners PAB and JHI voluntarily took the opportunity to run second year of insights in how polycultures and monocultures compare in real-world small-scale growing conditions experiment. PAB working with some of the same participants, improved the design with a new set of aims.

3.2.7 Results and Dissemination

The 2019 experiment is still in progress. A live version of this graph that updates automatically each time an experimenter records a new harvest can be accessed here:

https://www.permaculture.org.uk/research/three-sisters-polyculture-experiment-2019

Experiment findings have been disseminated to participants, the public and researchers through several written and face to face channels as the work was ongoing. Some of the channels have been mentioned already in this deliverables, such as the Experimenter's online meet ups (August, September, October 2018) and the World Soil's Day Webinar, December 2018. The results were also disseminated at other public events as listed below (each reference shows in brackets the main audience group addressed):

- van der Velden, N.K., Hager, G. 2018. *GROWing collaborative research into permaculture practices* [Presentation, plus workshops]. National Permaculture Convergence (Manchester, UK, September 2018) [Experimenters and wider Stakeholders]
- Permaculture Association, 2019. *The Great GROW Experiment* [website] Available at: https://www.permaculture.org.uk/research/great-grow-experiment (Accessed October 2019) [Public]

- Garden Variety Research [Facebook page] available at: https://www.facebook.com/groups/gardenvarietyresearch (Accessed October 2019) [Experimenters and wider Stakeholders]
- Burton, V., van der Velden, N.K. 2019. Poking it with a stick: The evolution of citizen Science. *Permaculture Works* Summer 2019 ed. [Stakeholders]
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- van der Velden, N.K., Burton, V., 2019. *Citizen science, soils, permaculture and GROWing*. [Presentation, plus workshops] National Permaculture Convergence. Oxford, UK September 2019 [Stakeholders]
- van der Velden, N.K., 2019. Growing Food for a Sustainable Future *The Ecologist*. Available at: https://theecologist.org/2019/apr/17/growing-food-sustainable-future [Accessed October 2019]

Academics publications and presentations were also carried out and are listed in detail in Deliverable 2.5 *Evaluation of Citizen Engagement and Active Participation*. Additionally, the approach has documented and shared in two articles in Medium: *Polycultures v. monocultures - the Great GROW Experiment 2018* (https://medium.com/grow-observatory-blog/polycultures-v-monocultures-the-great-grow-experiment-2018-5fac8a6a3879 and *So how did we design the Great GROW Experiment?* (https://medium.com/grow-observatory-blog/so-how-did-we-design-the-great-grow-experiment-962da8f9202).

3.3 Edible Plant Database: Validating growing advice through citizen science

GROW's Edible Plant Database (EPD) provides information, and local growing advice on more than 140 edible plants. These plants range from the most common vegetables and herbs, which tend to be annually planted, to soft fruit and larger fruit and nut trees. The EPD is a combination of scientifically and user contributed elements.

To help users plan which plants to grow, where, and how to group them, the best growing practices are described. Details of practices and cultivation groups were detailed in Deliverable 1.3 *Missions Toolkit*. Below we describe the citizen science activity designed to crowdsource growers' planting and harvesting data and present the participation levels achieved.

3.3.1 Planting and Harvesting Dates

The GROW Observatory app has calendars that display ideal planting and harvesting dates for most climatic regions within Europe.

The GROW team used European Climatic zones, as described by Metzger and colleagues (2005), that combines the climate and topography of Europe, to describe 12 main environmental zones and 84 strata (sub zones). The zones range from the cooler climate of the Alpine North and Boreal regions, where cold winter temperatures and short days limit the growing season to a few summer months, to the warmer drier regions of the Mediterranean South, where growing seasons are almost all year round and low rainfall and high temperatures are the limiting factors.

As growers learn about their local environment and micro climates, they adjust planting and sowing times given on the back of seed packets to suit their local climate. GROW collected planting and harvesting information from growers across Europe. When two people within a full or sub zone confirmed the dates in our database, or suggested different dates, the GROW team added that information to the EPD and shared these results in the app. The planting and harvesting data are displayed as “the beginning of the month” or “end of the month” (i.e. in 24 half month periods during the year). That is, when growers record their planting date as, for example, 6th March, this is recorded as the beginning of March.

3.3.2 Participation methods for GROW’s EDP

There were two ways to contribute:

- On Facebook: the Facebook page “Share My Planting Calendars” is a group where growers can discuss their growing practices; the group ran fortnightly polls asking, “what are you planting/harvesting now”.
- By email: Users could also send their planting and harvesting calendar using the email address calendars@growobservatory.org. People emailing were sent the current calendar for their area.

3.3.3 Method

The calendars being used for the EPD were collated using information from seed catalogues (Dobbies and Suttons) and web pages (www.growveg.co.uk, www.rhs.org.uk). UK examples have shown that these are often generalised and inaccurate. To address this lack of accurate data, crowd sourcing through citizen scientist was implemented. To validate the calendars 2-week windows or dates

were needed, and several methods were used to collect information from growers. These methods were:

- A crop survey (created using Bristol Online Surveys).
- Distribution of calendars at events.
- Sponsored Facebook polls.
- Sponsored twitter polls.
- Facebook posts asking for planting and harvesting information about single crops.
- Facebook posts, using the poll functionality, asking "what are you sowing/planting now?", using polls (see figure below 3.12).

The Facebook group "Share my planting calendars" was set up. Sponsored posts, targeting growers, directed them to the page, and the GROW app had text added to each crop asking:

- *"Are you getting plant recommendations or planting/harvesting dates that don't fit with your location, timing and experience?*
- *"Share your insights and help us improve our data – join the GROW Observatory: "Share Your Planting Calendars" activity on Facebook."*

3.3.4 Results

The method that generated usable data was posting polls at the beginning, and the middle of each month, asking members what they were planting or harvesting in the next 2 weeks which aligns with the dates in our calendars. The resulting data from this strategy, over a period of 5 months, yielded over 500 usable data points for harvesting, and over 1100 data points for planting.

Data was stored in an excel table, consisting of crop, poll date, poll type (planting or harvesting), username, location (where available), European climatic zone, and European climatic sub-zone. Data included in the validation process to update for the app consists of a total of 1751 data points from 108 individuals (data up to the 31st July).

These data consist of 91 edible plants, covering 8 of the 12 European climate zones. Of the 1751 data points, 171 (from 28 contributors) were unusable due to having an unknown location.

The final validated dates (any date with >2 votes) were compared with the original calendars resulting in 41 crops having validated dates (19 in Atlantic Central region and 22 in Atlantic North) and 36 crops with crowd sourced dates (16 in Atlantic Central region and 20 in Atlantic North) see figure (3.13) as an example of crowd sourced planting date.

Figure 3.12. Harvest poll showing votes for the top 5 crops from a total of 46

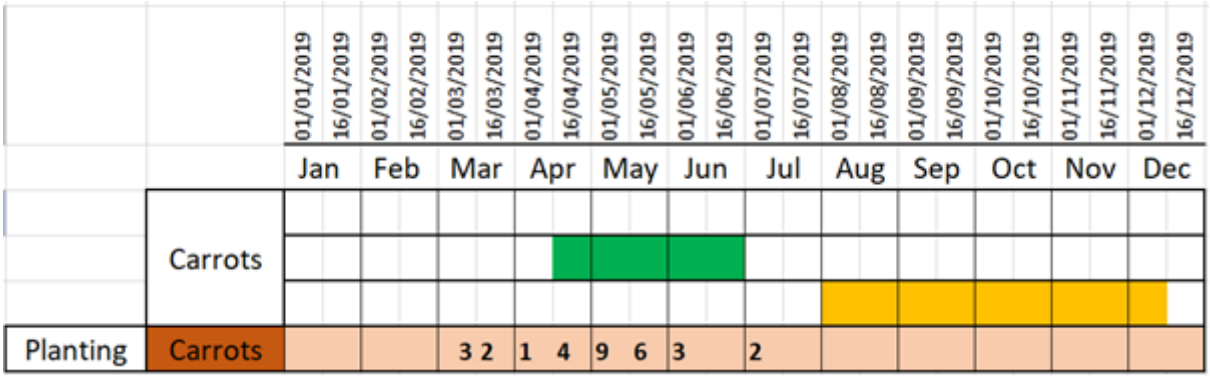


Figure 3.13. Number of votes for planting carrots in one region, resulting in the date for planting carrots, through knowledge of growers in that region, planting 6 weeks earlier than our calendars indicate.

In total, the level of engagement and number of submissions achieved is listed below:

- 535 page members
- 1570 data submissions

- 29 (ATN) - end June
- 19 (ATC) - end June
- changes or confirmations of crop planting times
- Updated in App August 2019

All the EPD data are open-sourced, and the 12 calendars (one for each European zone) for the 140 plants will be available for download at the end of the project.

4. Innovations, Impacts and Next Steps for Citizens Observatories

In sections 2 and 3 we have presented important results that shed light on emergent innovations that GROW able to report at the end of the funded period. We now draw together and highlight these key innovations and impacts, to reflect on the achievement as well as describe the current landscape for continuation from a participant perspective. We also bring together additional anecdotal feedback gathered in workshops and user stories, and available on the GROW Medium channel.

From the evaluation, we have seen 24 mission outcomes around the adoption of sustainable land management practices, land use change, and validation of new land management and cultivation practices. These include 14 innovations that were emergent and not planned while setting up the project, and 10 cases of policy engagement and uptake. We summarise them here under WP1 achievements.

4.1 Social Innovation

The science and resultant data sharing practices adopted in GROW has been made useful to local communities. We see real impact on the ground in communities that includes changes in practice such as a reduction in water use and management for crop production in the Canary Isles, new community design visualisations using local sensor data to monitor and manage soil moisture on a farm in Portugal threatened with wild fires, and improvement in information sharing, resources and knowledge of regenerative growing practices.

- In the Canary Islands, after just one month collecting and accessing GROW sensor data, two banana farmers in el Hierro realised that they were over irrigating their crops, and as a result they have reduced the use of water for irrigation by between “30 - 50%"

- Giorgos Galetsas, a Forester working with the National Park, uses the sensor data to understand the behaviour of migratory bird in relation to soil moisture and to inform policy making. He combines soil moisture data with other GIS data to monitor flooding in a Natura 2000 wetland (Evros Delta) which attracts protected migratory birds (anser erythropus).

- The growers from GROW Place Netherlands have collected evidence for and gained confidence in methods they follow. Peter from the Netherlands says, “Micro water management – in the ditches, with cover crops – works! GROW sensors show this!”

- Growers have found ways of using the soil moisture data to address their own critical issues, such as Walt in Portugal whose farm is threatened by desertification and wildfires. Walt wants to build on GROW to address this using an open software and hardware.

- Thousands of citizens, across all age demographics, both participating in and external to GROW, have been learning together through a series of transdisciplinary MOOCs, In total the education dimension represents 23 weeks of high quality learning experience that has brought learners together with scientists. It thus addresses a key aim to democratise science and value different types of expertise and knowledge. This has also enabled the project to build a thriving community of citizen scientists across Europe and beyond, who will continue to contribute to the legacy.

- People are motivated by local issues such as water resource, heatwaves, forest fires as well as the climate emergency linked to soil and food production. In GROW, these have different geographic context which link to personal motivations around the topic of soil moisture, growing and harvesting food. GROW has made a connection with people and demonstrated through data practices how they can begin to gather evidence and effect climate action.

4.2 Technology Innovation

Our results demonstrate that future technology for sensors will play an important role in creating opportunities for new distributed CO's. However, they also show that the success of this technology when coupled with the need for continuous monitoring should be determined over an extended period of time (e.g. months or years). Therefore, our findings highlight the need for longitudinal studies to better explore the impact of low cost sensors that are validated, robust, and environmentally sound in order to address the community concerns of e-waste. GROW delivered a DiY sensor workshop to demonstrate the potential for open hardware and software in the field. This was well received with Community Champions each receiving an alternative open source soil moisture sensor, which many went on to register and compare data with the flower power sensor.

- We have seen technical challenges arise, whilst anticipated these have impacted on flow of data, and have tested participants in terms of time, ability to problem solve and report. Maintaining sensors, updating firmware and uploading data were reported, there were also issues with correct location co-ordinates. These issues meant GROW, unlike other initiatives that have monitoring periods rather than continuous data gathering, had to set up a technical team to respond, a role that had been assigned to the technology provider.

- An unanticipated but obvious technical issue was the lifespan of the flower power sensor itself, which varied in different climatic conditions and

across seasons. We do not do into the analysis of that here, but report from a usability perspective, for citizens, a product from a well-designed commercial package subliminally indicated that a sensor would be robust. Whilst on average the flower power sensor lifespan was three time a comparable open source sensor, the construction was not equivalent to more professional models.

4.3 CO Model in Action

Finally, we consider a significant innovation is in demonstrating the evolving and iterative development of a CO model and framework 'in action', that is both adhering to complex scientific protocols, whilst building community and providing data to address local contextual goals. To recognize achieve this, and see tangible results is truly significant as requires a maturation of the ecosystem of people, technology and practices. We have seen early uptake from citizens, grassroots and community networks, and later when results emerge, demonstrable interest from scientific, education and government institutes. We posit that in the maturation of a CO ecosystem, consideration should be given to the iterative cycles of amplification and replication to bring additional institutional stakeholders to the community, they may themselves become community champions of sorts. Together iterative cycles are capable of leveraging local funds, engaging with local issues, and supporting citizens in practice. GROW has demonstrated that this can and has been achieved, and this is a clear indicator of the route to sustainability.

- An early career researcher has used GROW sensors as part of her research within the FLASHFLOOD project, aiming to set up a pilot hydro-meteorological monitoring system adapted to local and sudden events such as summer storms and flash floods. The participation in the GROW project is an opportunity for FLASHFLOOD researchers to multiply the humidity measurement points on the different soil types, micro-topography and geologies that characterize the Ernz Blanche basin.

- In Wieselburg, Austria, the AGES Institute has used moisture measurements complemented the tea bag index experiment designed by TU Wien with school children.

- Science institutes involved in GROW Places are building on GROW by discovering novel applications of the data. In Italy, the data is being used for hydrologic modelling by Politecnico Di Milano.

- In Slovenia, the community champion aims to include the data in the thesis of her master of research.

- In Greece, GROW has led to a local, spin-off project called KOINO EDAFOS ("Common Ground") which received €50K funding from the Greek Green Fund to design and implement citizens' workshops, awareness campaigns,

and an open educational toolkit on soil for schools on soil protection & regeneration in the region of Evros.

4.4 Community Engagement with Policy

Citizens often cite policy as an area they do not feel they have any agency in. GROW has seen specific and direct examples, described in detail in section 2, of the power of policy engagement for impact and outcomes. GROW has, where possible, leveraged its position to enter in dialogue with policy-makers. Not waiting for results to create opportunities for debate and dialogue. The GROW Public Event "Citizens & Open Data for Sustainable Development" is a case in point, and CO's should be mindful of these opportunities, particularly utilising the medium of video to capture statements from policy makers that in turn can validate and encourage citizens scientists.

- Encouraged by this the GROW Community Lead with members of GROW Place Greece led the creation of a new independent political group, FAROS meaning lighthouse, with a campaign centred on the SDG's.

- Local Government (Cabildo) Department of Agriculture in the canaries has also become a part of the GROW community. They have deployed 123 sensors, installed by the Community Champion, on their government land, and cover nearly all climate zones in the island.

- In Luxembourg, we see the forestry and nature administration acting as a superuser, distributing 300 sensors to forester. They aim to have a good coverage of soil data humidity and temperature in forests. This dataset is intended to be integrated into an ongoing study with other forest parameters.

4.5 Novel Tools and Evaluation

WP1 in particular has leveraged its expertise in Service Design and Design Thinking, and has pioneered the development, validation and application of new tools to evaluate the success of CO's at scale. Citizen Science is a field where robust evaluation can be difficult to administer and achieve, particularly where participants are multiple, distributed and do not have English as their first language. These tools are particularly useful as they are deceptively easy to use, therefore enabling CC's to deliver them within their communities.

- Our Co-Design Climate Services Tool, won an award at ADIM2019, London, and has been successfully rolled out as a face to face workshop method that supports stakeholder to fully understand an operational CO, it's data flows and application. The tool, with additional SDG expansion pack will be made available with Creative Commons Licence for download. We have also

created design led canvases to probe participant motivations, and help stakeholders reflect on the changes they have seen across a range of indicators, as describe in section 2 of this report.

- Presenting Communities with the opportunity to refine case studies on their GROW Place has also been a stream of work that has yielded rich results. Providing robust evaluation of CO's is a step that requires consideration in order to value the experience and voice of many participants who give their time and energy to citizen science.

4.6 Next Steps

GROW Places will have access to cloud based services to continue to gather sensor data beyond the end of the funded period. In addition, social media channels will be maintained for the community with light moderation from key members of the team as long as they remain in use, and is practical. The wider community have been provided with a list a series of resources, learning and funding opportunities available in order to continue to support their interest. Communities have been encouraged to extend the list by including additional opportunities from their own areas/countries. The list included the following opportunities:

Online Learning

- Name: Citizen Science Projects: How to Make a Difference
- Date: 18 Nov 2019 for 4 weeks
- Link: Futurelearn https://www.futurelearn.com/courses/weobserve-the-earth
- Description: Information on how to build your own Citizens' Observatory from The GROW Observatory, Groundtruth 2.0, Scent, Landsense. This free online course is now open for enrollment. On this course, you can learn how to build your own citizen science project, and discover the citizen science projects available around the world - and how to get involved. You'll also find out how to lead a citizen science project, and how to interpret the data collected and use it to educate others about environmental concerns.

WeObserve Data hack

- Name: WeObserve Open Data Challenge
- Date: March 2020
- Link: https://www.weobserve.eu
- Description: Using environmental data on soil and land gathered from Citizens Observatories including GROW, Scent, Landsense and others this online open data challenge will focus on social innovation

GROW Observatory Protocols & Resources

- Knowledge Base Resources: https://knowledge.growobservatory.org/
- Regenerative Food Growing Practices: https://knowledge.growobservatory.org/article-categories/regenerative-food-growing-practices/
- Set up your own growing experiment: on the Knowledge Base, 31st October 2019

4. Other Citizen Science projects

- WeObserve: https://www.weobserve.eu/
- WeObserve Communities of Practice: https://www.weobserve.eu/cops/
- WeObserve Knowledge Base: https://www.weobserve.eu/knowledge-base/
- EU-Citizen Science: Coordinate, Engage and Create Citizen Science Projects - http://eu-citizen.science/
- ECSA: https://ecsa.citizen-science.net/
- https://www.scistarter.org/ - a database of citizen science projects

5. Funding Opportunities for communities and citizens:

- Erasmus+: https://www.erasmusplus.org.uk/apply-for-funding
- Electronic Platform for Adult Learning in Europe (EPALE): https://www.erasmusplus.org.uk/blog/how-epale-can-help-you-with-your-erasmus-project
- Adult learning programme: https://ec.europa.eu/programmes/erasmus-plus/opportunities/individuals/staff-training/adult-education_en
- Europe for citizens: https://eacea.ec.europa.eu/europe-for-citizens/news/call-for-proposals-networks-towns-2019-round-2_en
- Networks of Towns Open Call: https://eacea.ec.europa.eu/europe-for-citizens/funding/networks-towns-2019-round-2_en
- Civil Society projects: https://eacea.ec.europa.eu/europe-for-citizens/funding/civil-society-projects-2019_en
- Cost Actions: https://www.cost.eu/cost-actions/what-are-cost-actions/

5. Conclusions

Through the evaluation of Mission outcomes, we have reported on impacts and innovations in sustainable land management and food production practices that emerged bottom-up in the GROW H2020 project. In GROW, we introduced an emphasis on 'closing the loop' between scoping local issues, sensing missions, awareness and innovation built on data, and advocacy and implementation for impact. In GROW, some innovations were developed top-down, that is to say, they were envisioned in the proposal, responding to challenges identified in advance. These include validation of satellite soil moisture products, and the development of dynamic soil moisture maps. Other innovations emerged bottom-up, catalysed by participatory methodologies, increased networks and knowledge exchange activities within and amongst the members of the GROW Places. As a consequence several Community Champions and superusers have used data in an innovative way that was not planned while setting up the project.

This deliverable has summarised the achievements of activity in GROW focusing on the Living Soils and Changing Climate Missions in WP1 to engage and train thousands of people across Europe, demonstrating how the concept of COs can work in practice across a diverse range of cultural and geographical contexts. Sustainable soil management decisions rely on knowledge and on processing data collected on the field; the faster and more precise the analysis, the faster the decisions can be; GROW has promoted both aspects by fostering knowledge-intensive farming practices and empowering citizens to monitor their soil and test more regenerative food growing practices.

The Consortium has endeavored to ensure the development of all the resources and tools that have been designed to be easy to use, economically accessible and reliable. This will provide a legacy that will contribute into the future beyond the funded life of the project to further uptake of sustainable food cultivation methods to build on the impact already achieved in the last three years. These resources and networks promoting regenerative land management – within and beyond Europe’s borders – allow users to make decisions on-site and promptly react to help mitigate climate change and inspire others to follow similar practices to achieve both environmental and human health and prosperity. We hope the GROW Framework developed to inform the design and the underlying values of observatories activities, can become an asset to future consortia and communities keen to establish their own at scale observatories.

The Framework stages and values highlight the compromise and design awareness needed to achieve a balance amongst the different key variables Observatories have to juggle:

- Modulating participant and sensing reach in relation to quality training and data: the higher the number of participants, the higher the resources needed to train them to follow complex protocols on a robust manner.

- Modulating cost of sensing technology vs number of technical issues and training required: the lower the cost, the more likely COs are to encounter and deal with technical problems, which will require more resources for technical support and logistics (e.g. to replace faulty sensors).

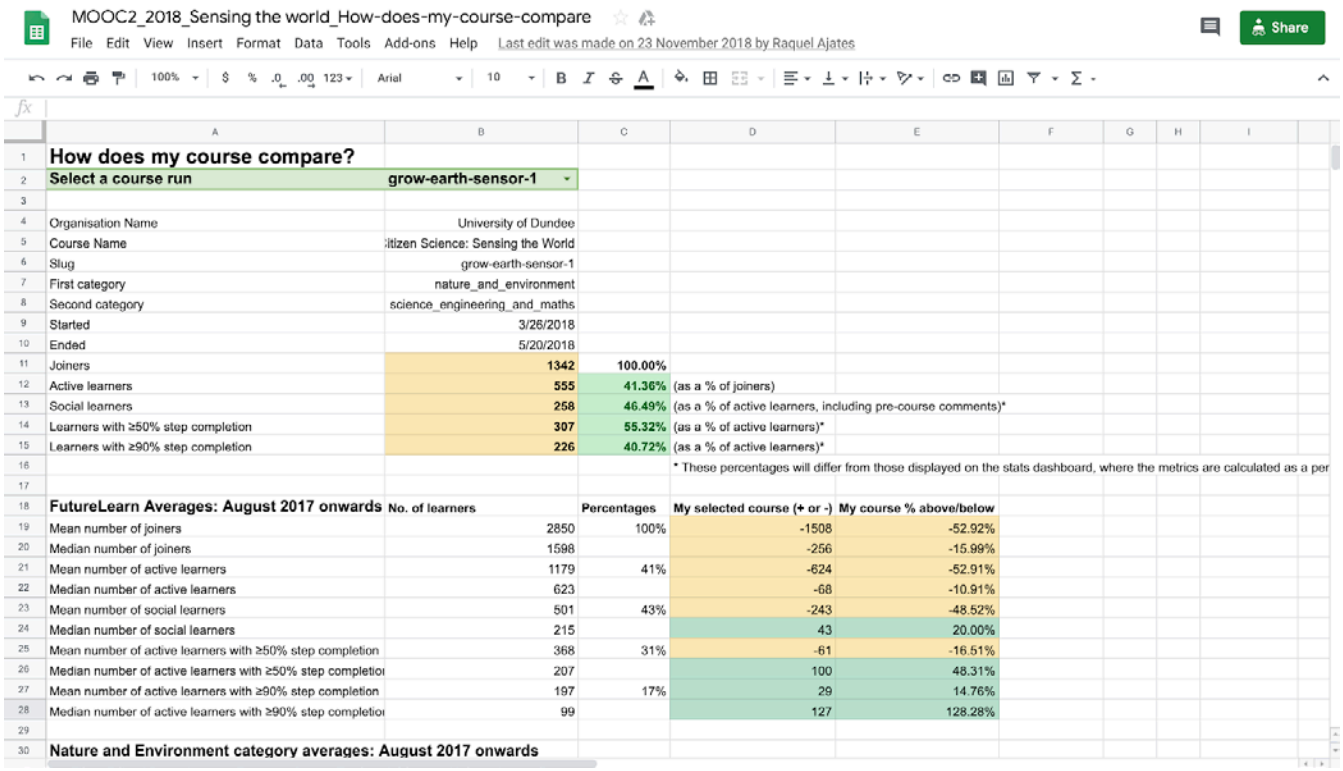
We have seen innovative uses of citizen-generated data in GROW Places already emerging, a sign of a maturing ecosystem of for innovation. The uptake and usability of the sensor data have been demonstrated, not just as a stand-alone database, but also in conjunction with other datasets. For example, in the Canary Islands participants are connecting vineyard yield data with sensor data. Colleagues in GROW Place Austria are testing the effectiveness of no/mulching techniques with tea-bag index data. In Greece, sensor data are being used in parallel with bird population data to assess how soil moisture affects migratory bird's patterns and protect their habitat accordingly. While running a Co-design for Climate Innovation workshop at the Transformations 2019 Conference in October 2019 in Chile, attendees representing different Chilean government departments highlighted the value of soil moisture data in countries with seismic activity. Buildings located in areas characterised by high soil moisture levels are more likely to collapse during an earthquake, and thus, soil moisture data are a valuable resource that can help inform better planning regulations for risk reduction. These examples demonstrate a glimpse of the widespread potential GROW's citizen generated can have for a wide range of environmental, agricultural and climate adaptation applications.

Finally, we would like to reflect on the type of CS promoted by GROW based on citizens' level of participation in the process of knowledge creation and in their degree of leadership for independent research. From the beginning of the project, GROW was tasked by the European Commission to demonstrate whether CS could help validate Sentinel-1 satellites soil moisture datasets at the continental scale, by distributing soil sensors across European communities (GROW Places). This was GROW's main hypothesis at its starting point, which could be considered as a contributory CS project in which citizens submit data but are not part of the research design or the data analysis (Shirk et al., 2012). However, opening data to users, being aware of local environmental contexts and issues, coupled with the design-led activities and resources created to train and empower participants to make sense of their own data, and carry out their own experiments, led to the emergence of collegial CS activities in several GPs as described in section 2 of this deliverable. Cases from Greece, Spain and the Netherlands amongst others illustrate how with the adequate training, community facilitation and an open data approach, COs and more widely CS contributory projects can give way to a positive *leaky pipeline* effect. We define the *leaky pipeline* as opendata at local level, thus promoting contextual experimentation, innovation and empowerment at a community level whilst, at the same time, addressing top down scientific objectives. We consider this represents the holy grail of data use for demonstrating our model and framework for CO's.

Appendix 1 – FutureLearn Course Run Measures

- Joiners are the number of currently existing enrolments made for that specific course run. This includes educators, admins alongside learners who currently have accounts on the platform.
- Leavers are users (of any role) who have chosen to no longer be a part of the course. Leavers are remain represented in the number of Joiners. Also presented as a percentage of joiners.
- Learners are users (of any role) who have at least viewed at least one step, at any time, in any course week. This includes those who go on to become Leavers. Also presented as a percentage of Joiners.
- The average number of Learners on a course is 62.2% of Joiners.*
- Active Learners are those (of any role) who have completed at least one step at any time in any course week, including those who go on to become Leavers. Completion varies by step type, with some requiring additional user interaction (e.g. “mark as complete”) while others are completed through submission (Assignment, Review) and question attempts (Quizzes & Tests). Also presented as a percentage of Learners.
- The average number of Active Learners on a course is 65.8% of Learners.*
- Social Learners are those (of any role) who have posted at least one comment on any step. Also presented as a percentage of Learners.
- The average number of Social Learners on a course is 28.3% of Learners.*
- Learners who’ve marked 50% or more of steps complete represents users (of any role) who have successfully completed 50% or more of the steps contained within the course.
- The average number of 50% or more steps completed is 21.3% of Learners.*
- Learners who’ve marked 90% or more of steps complete represents users (of any role) who have successfully completed 90% or more of the steps contained within the course.
- The average number of 50% or more steps completed is 14.1% of Learners.*
- Note: For a course that contains Tests or Quizzes: these are considered ‘marked as complete’ when a learner has attempted each question at least once.
- * Accurate as of November 2018 based on all open, discoverable courses from 1 Aug 2017 – 31 July 2018 (read more).
- Deprecated course run measures (available for course runs that started before 6 March 2017)
- Fully Participating Learners are those who have completed at least 50% of the available steps on a course. On courses containing tests, they must also complete them. Test completion is defined as all non-voided questions having been attempted regardless of result. Learners cannot be counted as fully participating until all the weeks of a course have been published and are visible to them.
- The average number of fully participating learners on a course is 21% of learners.**
- Returning Learners are those who completed at least a step in at least two distinct course weeks. These do not have to be sequential or consecutive, nor completed in different calendar weeks. This is also presented as a percentage of learners.
- The average number of returning learners on a course is 40% of learners.**
- ** Accurate as of September 2015 based on courses starting in 2014/15 academic year (read more).

Appendix 2 – Comparative enrolment figures for other FutureLearn courses in same subject category as GROW MOOCs



MOOC2_2018_Sensing the world_How-does-my-course-compare

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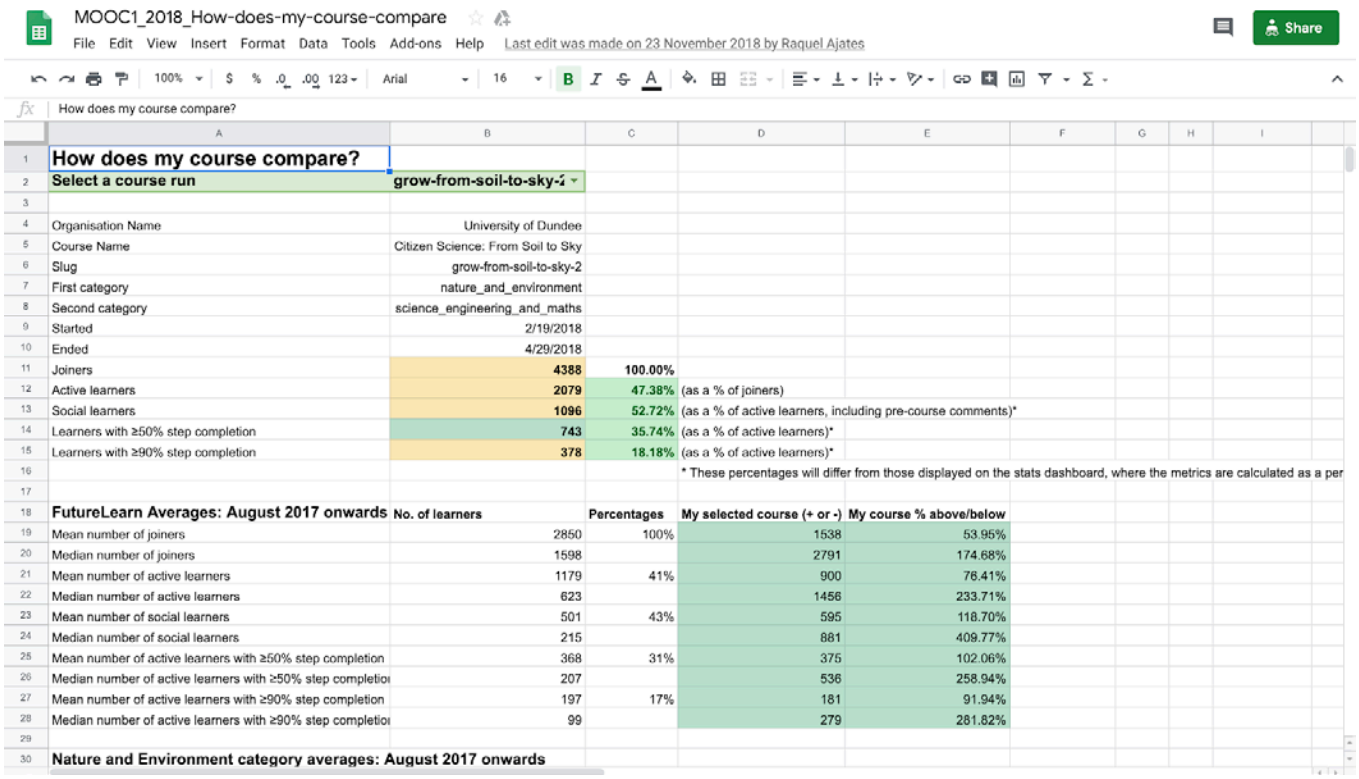
Share

	A	B	C	D	E	F	G	H	I
1	**How does my course compare?**								
2	**Select a course run**	**grow-earth-sensor-1**							
3									
4	Organisation Name	University of Dundee							
5	Course Name	itizen Science: Sensing the World							
6	Slug	grow-earth-sensor-1							
7	First category	nature_and_environment							
8	Second category	science_engineering_and_maths							
9	Started	3/26/2018							
10	Ended	5/20/2018							
11	Joiners	**1342**	**100.00%**						
12	Active learners	**555**	**41.36%**	(as a % of joiners)					
13	Social learners	**258**	**46.49%**	(as a % of active learners, including pre-course comments)*					
14	Learners with ≥50% step completion	**307**	**55.32%**	(as a % of active learners)*					
15	Learners with ≥90% step completion	**226**	**40.72%**	(as a % of active learners)*					
16				* These percentages will differ from those displayed on the stats dashboard, where the metrics are calculated as a per					
17									
18	**FutureLearn Averages: August 2017 onwards**	**No. of learners**	**Percentages**	**My selected course (+ or -)**	**My course % above/below**				
19	Mean number of joiners	2850	100%	-1508	-52.92%				
20	Median number of joiners	1598		-256	-15.99%				
21	Mean number of active learners	1179	41%	-624	-52.91%				
22	Median number of active learners	623		-68	-10.91%				
23	Mean number of social learners	501	43%	-243	-48.52%				
24	Median number of social learners	215		43	20.00%				
25	Mean number of active learners with ≥50% step completion	368	31%	-61	-16.51%				
26	Median number of active learners with ≥50% step completio	207		100	48.31%				
27	Mean number of active learners with ≥90% step completion	197	17%	29	14.76%				
28	Median number of active learners with ≥90% step completio	99		127	128.28%				
29									
30	**Nature and Environment category averages: August 2017 onwards**								



MOOC1_2018_How-does-my-course-compare

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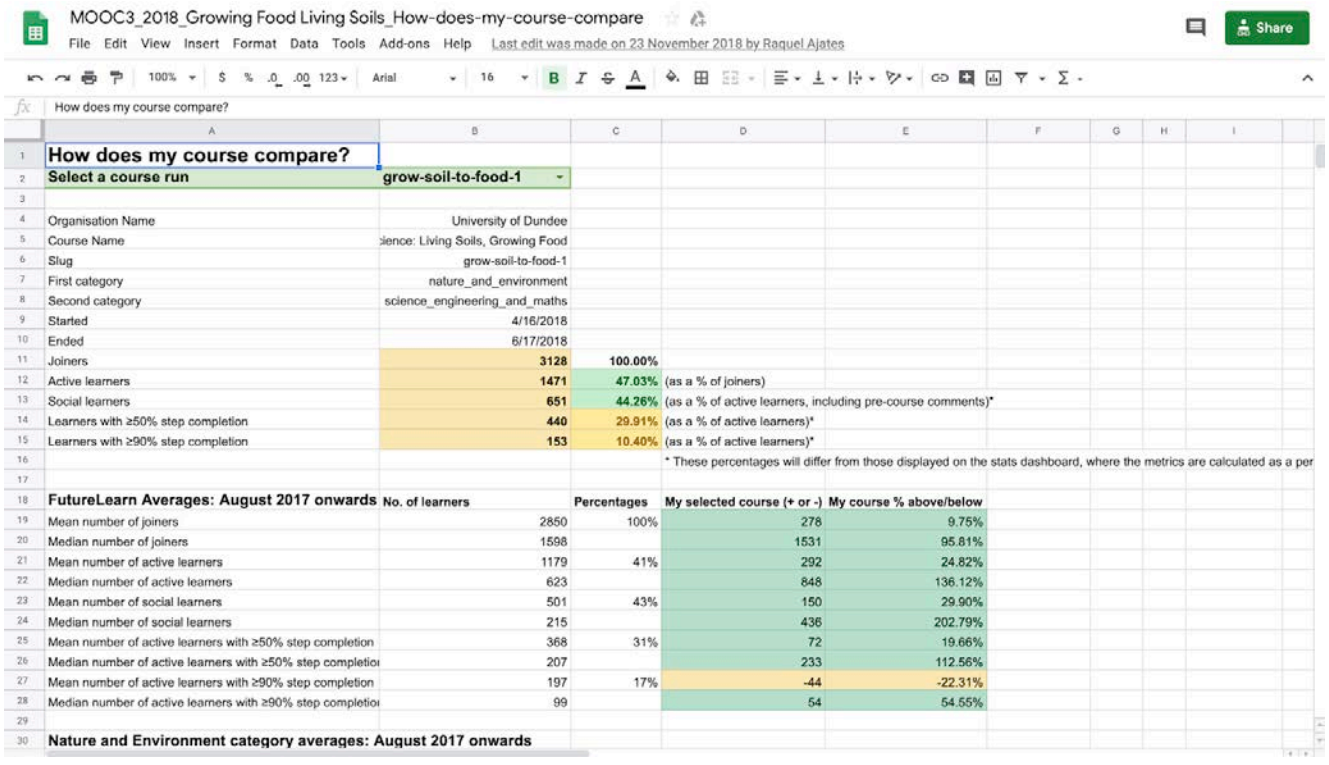
Share

How does my course compare?

How does my course compare?					
Select a course run	**grow-from-soil-to-sky-1**				
Organisation Name	University of Dundee				
Course Name	Citizen Science: From Soil to Sky				
Slug	grow-from-soil-to-sky-2				
First category	nature_and_environment				
Second category	science_engineering_and_maths				
Started	2/19/2018				
Ended	4/29/2018				
Joiners	**4388**	**100.00%**			
Active learners	**2079**	**47.38%**	(as a % of joiners)		
Social learners	**1096**	**52.72%**	(as a % of active learners, including pre-course comments)*		
Learners with ≥50% step completion	**743**	**35.74%**	(as a % of active learners)*		
Learners with ≥90% step completion	**378**	**18.18%**	(as a % of active learners)*		
			* These percentages will differ from those displayed on the stats dashboard, where the metrics are calculated as a per		
FutureLearn Averages: August 2017 onwards	**No. of learners**	**Percentages**	**My selected course (+ or -)**	**My course % above/below**	
Mean number of joiners	2850	100%	1538	53.95%	
Median number of joiners	1598		2791	174.68%	
Mean number of active learners	1179	41%	900	76.41%	
Median number of active learners	623		1456	233.71%	
Mean number of social learners	501	43%	595	118.70%	
Median number of social learners	215		881	409.77%	
Mean number of active learners with ≥50% step completion	368	31%	375	102.06%	
Median number of active learners with ≥50% step completio	207		536	258.94%	
Mean number of active learners with ≥90% step completion	197	17%	181	91.94%	
Median number of active learners with ≥90% step completio	99		279	281.82%	
Nature and Environment category averages: August 2017 onwards					



MOOC3_2018_Growing Food Living Soils_How-does-my-course-compare

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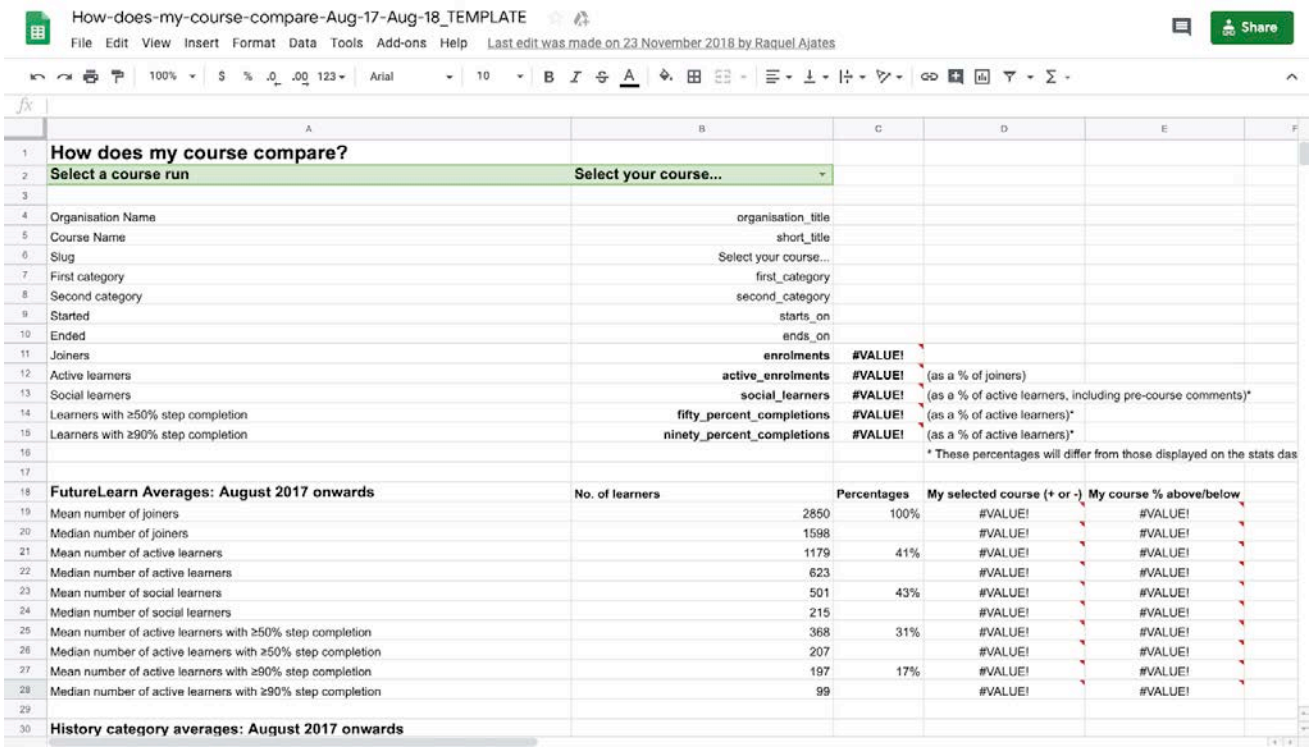
How does my course compare?

How does my course compare?					
Select a course run	**grow-soil-to-food-1**				
Organisation Name	University of Dundee				
Course Name	ience: Living Soils, Growing Food				
Slug	grow-soil-to-food-1				
First category	nature_and_environment				
Second category	science_engineering_and_maths				
Started	4/16/2018				
Ended	6/17/2018				
Joiners	**3128**	**100.00%**			
Active learners	**1471**	**47.03%**	(as a % of joiners)		
Social learners	**651**	**44.26%**	(as a % of active learners, including pre-course comments)*		
Learners with ≥50% step completion	**440**	**29.91%**	(as a % of active learners)*		
Learners with ≥90% step completion	**153**	**10.40%**	(as a % of active learners)*		
			* These percentages will differ from those displayed on the stats dashboard, where the metrics are calculated as a per		
FutureLearn Averages: August 2017 onwards	**No. of learners**	**Percentages**	**My selected course (+ or -)**	**My course % above/below**	
Mean number of joiners	2850	100%	278	9.75%	
Median number of joiners	1598		1531	95.81%	
Mean number of active learners	1179	41%	292	24.82%	
Median number of active learners	623		848	136.12%	
Mean number of social learners	501	43%	150	29.90%	
Median number of social learners	215		436	202.79%	
Mean number of active learners with ≥50% step completion	368	31%	72	19.66%	
Median number of active learners with ≥50% step completio	207		233	112.56%	
Mean number of active learners with ≥90% step completion	197	17%	-44	-22.31%	
Median number of active learners with ≥90% step completio	99		54	54.55%	
Nature and Environment category averages: August 2017 onwards					



How-does-my-course-compare-Aug-17-Aug-18_TEMPLATE

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	A	B	C	D	E
1	**How does my course compare?**				
2	**Select a course run**	**Select your course...**			
3					
4	Organisation Name	organisation_title			
5	Course Name	short_title			
6	Slug	Select your course...			
7	First category	first_category			
8	Second category	second_category			
9	Started	starts_on			
10	Ended	ends_on			
11	Joiners	**enrolments**	**#VALUE!**		
12	Active learners	**active_enrolments**	**#VALUE!**	(as a % of joiners)	
13	Social learners	**social_learners**	**#VALUE!**	(as a % of active learners, including pre-course comments)*	
14	Learners with ≥50% step completion	**fifty_percent_completions**	**#VALUE!**	(as a % of active learners)*	
15	Learners with ≥90% step completion	**ninety_percent_completions**	**#VALUE!**	(as a % of active learners)*	
16				* These percentages will differ from those displayed on the stats das	
17					
18	**FutureLearn Averages: August 2017 onwards**	**No. of learners**	**Percentages**	**My selected course (+ or -)**	**My course % above/below**
19	Mean number of joiners	2850	100%	#VALUE!	#VALUE!
20	Median number of joiners	1598		#VALUE!	#VALUE!
21	Mean number of active learners	1179	41%	#VALUE!	#VALUE!
22	Median number of active learners	623		#VALUE!	#VALUE!
23	Mean number of social learners	501	43%	#VALUE!	#VALUE!
24	Median number of social learners	215		#VALUE!	#VALUE!
25	Mean number of active learners with ≥50% step completion	368	31%	#VALUE!	#VALUE!
26	Median number of active learners with ≥50% step completion	207		#VALUE!	#VALUE!
27	Mean number of active learners with ≥90% step completion	197	17%	#VALUE!	#VALUE!
28	Median number of active learners with ≥90% step completion	99		#VALUE!	#VALUE!
29					
30	**History category averages: August 2017 onwards**				

Appendix 3 - Case study Proforma

GROW Place:	
Location	
Community Champion(s):	
# of sensors deployed at your GROW Place:	*(how many sensors did you distribute to Mission participants at your GROW Place)*
# of total participants:	*(how many sensor users in the Changing Climate Mission at your GROW Place - pls. indicate number of sensor users)*
# of total events (if applicable)	*(how many GROW events/meet-ups did you organise at your GROW Place - list of names and scope of each event)*

Background and Context *Cultural, political, economic and geographical context of the GROW Place (GP)*
Please tell us more about your GROW Place (climate, geography, main community priorities and socio-economic challenges.

Rationale of GROW Data Use at your GROW Place *Are there any GROW insights or community aspects that can be utilised by researchers or decision makers in your region/country?*
pls. mention specific programmes/projects or other opportunities for data exploitation at your GROW Place

Motivations for joining GROW *What are the main motivations of you as a Community Champion and users in your GROW Place for joining GROW's Mission?*
pls. make a distinction according to the context of these motivations, e.g.:

- *personal:*
- *local:*
- *global:*

Profile of Sensor Users
What are the main types of individuals or communities that participate in GROW's Changing Climate Mission at your GROW Place?

Please outline the different user personas (ie. individual, small farmers, large farmers, communities, research organisations, farmer's associations, etc) that have deployed sensors. Do you have an estimate of how many sensor users fall under each category?

Main Findings
Are there any concrete findings stemming from the evidence of your sensor data or any other observations that you did during the Changing Climate Mission?

Please tell us about how your participation in GROW has influenced your growing practices knowledge and interests. Did you get what you expected? What did work what did not work so well?

Also, what can we say about community building at your GROW Place? Were the participants responsive to your call for joining the Mission? What, if any, were the barriers to participation? What were the main challenges and opportunities that you encountered during the Mission?

The impact of GROW at your area
Are there any indications for the sustainability and longevity of the project at your area? Any policy implications, or opportunities for collaboration with other projects?

Please indicate any emerging stories, media coverage, advocacy or measurable impact that stems from the Changing Climate Mission at your GROW Place. This also includes conceptual changes, like changes in practices/mindsets/behaviours/attitudes and public narratives that might lead to policy change

Limitations and opportunities for future work *Are there any unexpected activities, feedback or anything that was out of the scope of the Mission but could be included or improved in future GROW activities*

Other *Please use this space to add any comments and thoughts that were not captured through the questions above*

Dissemination & Publicity *Please list any articles or publications about GROW at your GROW Place or country*

Appendix 4 – Evaluation Canvas

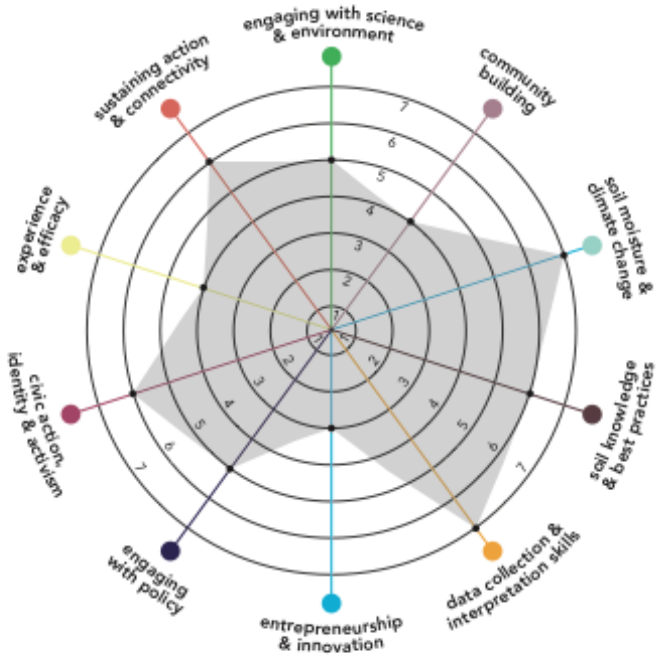
GROW EVALUATION TOOL

The GROW Evaluation tool aims to capture on how participating in this project has changed your knowledge, practices and interest about soil, science, and environment. This framework focuses on ten indicators of the impact resulting from this project. It provides prompting questions for discussions, allowing you to consider these indicators in a methodical way.

You will need to do the following:

- Record your GROW Place and note if you are completing the tool as an individual participant or a community champion representing a group or a community.
- Answer each question by giving a rating on a scale from 1 to 7. Use the space provided below the questions for your comments.
- When you have answered all the questions, plot each rating on the diagram on the last page.

Here is an example of the completed diagram:



GROW PLACE:

GROW Observatory has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690199.

1

Engaging with Science & Environment

Reflecting on your participation in GROW Observatory, ask yourself:

- *Has participating in GROW Observatory motivated you to learn and use science?*
- *To what extent have you become interested in and excited about facts, explanations and models related to science and environment?*

Next, rate the project on a scale from 1 to 7, where 1 means the project has created the lowest impact and 7 means the highest impact. Record your rating on the compass diagram. Use the space below to note the reasons for your rating.

Community Building

Reflecting on your participation in GROW Observatory, ask yourself:

- *How has participating in GROW Observatory enhanced your community?*
- *To what extent has GROW strengthen the communication and networks in your community?*

Next, rate the project on a scale from 1 to 7, where 1 means the project has created the lowest impact and 7 means the highest impact. Record your rating on the compass diagram. Use the space below to note the reasons for your rating.

2

Soil Moisture & Climate Change

Reflecting on your participation in GROW Observatory, ask yourself:

• *How has participating in GROW Observatory contributed to improving your understanding soil moisture and climate change?*

Next, rate the project on a scale from 1 to 7, where 1 means the project has created the lowest impact and 7 means the highest impact. Record your rating on the compass diagram. Use the space below to note the reasons for your rating.

Soil Knowledge & Best Practices

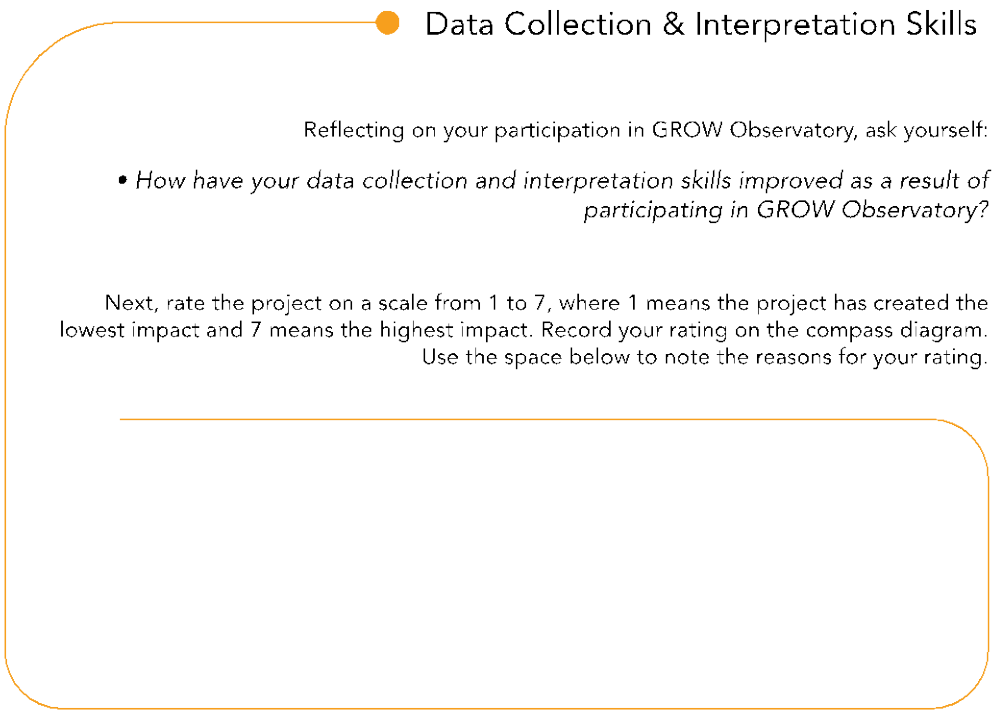
Reflecting on your participation in GROW Observatory, ask yourself:

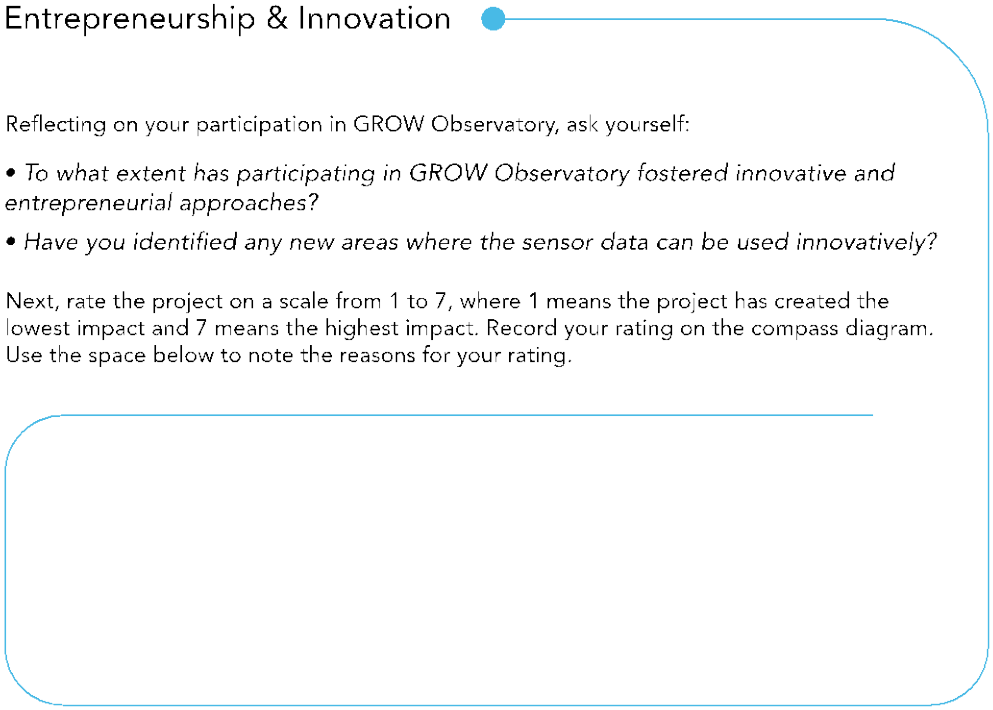
• *How has participating in GROW Observatory improved your growing practices?*

• *Have you learned more about ecological growing practices?*
(eg. regenerative agriculture, agroecology, permaculture)

Next, rate the project on a scale from 1 to 7, where 1 means the project has created the lowest impact and 7 means the highest impact. Record your rating on the compass diagram. Use the space below to note the reasons for your rating.

3


Data Collection & Interpretation Skills
Reflecting on your participation in GROW Observatory, ask yourself:
• How have your data collection and interpretation skills improved as a result of participating in GROW Observatory?
Next, rate the project on a scale from 1 to 7, where 1 means the project has created the lowest impact and 7 means the highest impact. Record your rating on the compass diagram. Use the space below to note the reasons for your rating.


Entrepreneurship & Innovation
Reflecting on your participation in GROW Observatory, ask yourself:
• To what extent has participating in GROW Observatory fostered innovative and entrepreneurial approaches?
• Have you identified any new areas where the sensor data can be used innovatively?
Next, rate the project on a scale from 1 to 7, where 1 means the project has created the lowest impact and 7 means the highest impact. Record your rating on the compass diagram. Use the space below to note the reasons for your rating.

4

Engaging with Policy

Reflecting on your participation in GROW Observatory, ask yourself:

- *Have you had any interactions with policy makers? eg. visits from policy makers, writing a letter to your local council.*
- *Have you identified local policy problems the sensor data can help solve?*

Next, rate the project on a scale from 1 to 7, where 1 means the project has created the lowest impact and 7 means the highest impact. Record your rating on the compass diagram. Use the space below to note the reasons for your rating.

Civic Action, Identity, & Activism

Reflecting on your participation in GROW Observatory, ask yourself:

- *To what extent has participating in GROW Observatory contributed to your identity as someone who knows about, uses, and sometimes contributes to science?*
- *Do you consider yourself as an active citizen?*

Next, rate the project on a scale from 1 to 7, where 1 means the project has created the lowest impact and 7 means the highest impact. Record your rating on the compass diagram. Use the space below to note the reasons for your rating.

5

Experience & Efficacy

Reflecting on your participation in GROW Observatory, ask yourself:

- *How has participating in GROW Observatory inspired and energised you?*
- *To what extent is the value created worth the time and effort you put into this project?*

Next, rate the project on a scale from 1 to 7, where 1 means the project has created the lowest impact and 7 means the highest impact. Record your rating on the compass diagram. Use the space below to note the reasons for your rating.

Sustaining Action & Connectivity

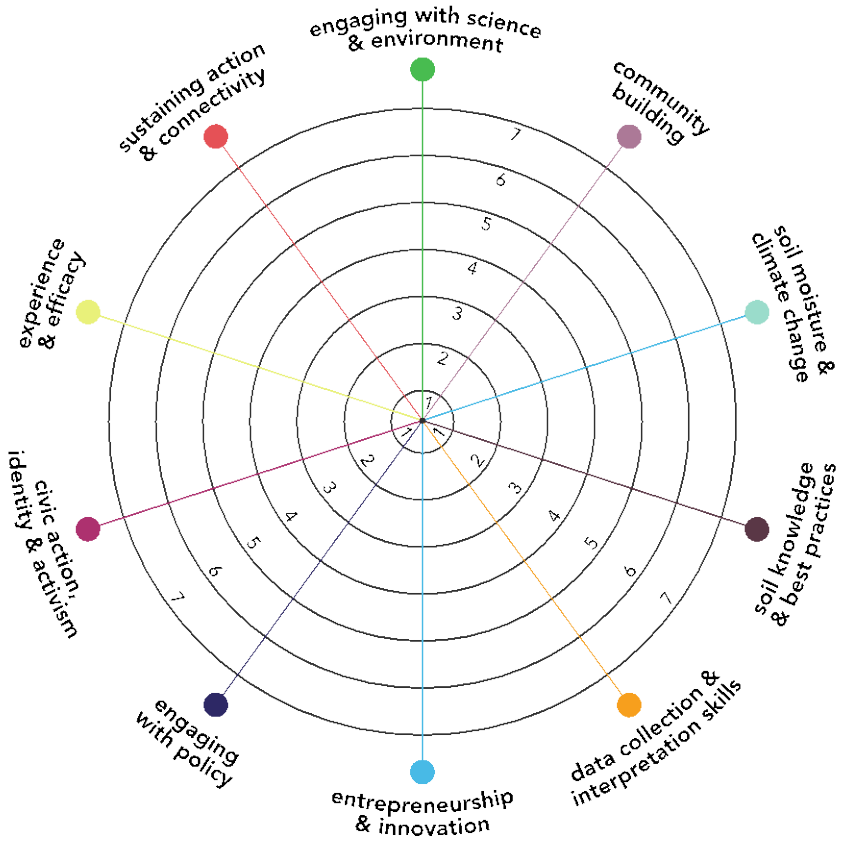
Reflecting on your participation in GROW Observatory, ask yourself:

- *How likely are you going to carry on recording soil moisture and associated data after the project ends?*
- *How likely are you going to stay in contact with your GROW community?*

Next, rate the project on a scale from 1 to 7, where 1 means the project has created the lowest impact and 7 means the highest impact. Record your rating on the compass diagram. Use the space below to note the reasons for your rating.

6

When you have answered all the questions, plot each rating on the diagram below.



GROW PLACE:

7

- END OF DOCUMENT -